United States Department of Agriculture

Office of the Chief Information Officer
Telecommunications Services and Operations
Network Engineering Division

Telecommunications Enterprise Network Design

Volume Three

Project Financial Evaluation

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Executive Summary: Financial Analysis of Alternatives - Part One

This financial analysis has been undertaken pursuant to the Telecommunications Network Stabilization and Migration Program (TNSMP), which responded to perceived inadequacies in the provision and management of telecommunications services within the U.S. Department of Agriculture (USDA). As a result of the assessment of telecommunications within USDA, the Telecommunications Enterprise Network (TEN) project was initiated to address issues within the current environment of disparate networks that have produced the following results:

- Inability to leverage network infrastructure and support capabilities on a department-wide basis to ensure proactive management of telecommunications resources, anticipating and addressing changes to requirements driven by technological advances and mission evolution
- Unacceptably high levels of network outages and bottlenecks resulting in operational effects.
- Prevalent bandwidth over-capacity, which increases the transmission cost without achieving compensating gains in network survivability or reliability.

In response to requirements for reliable network performance, proactive management of USDA's telecommunications environment is expected to yield efficiencies in the use of infrastructure and support capabilities, to minimize outages and bottlenecks, and to enable greater responsiveness to changing requirements.

Through in-depth analysis of the current utilization, anticipated trends, and related factors, the TEN project team has determined various alternative means of providing an enterprise network. These alternative approaches are identified in the document entitled Development of Initial Enterprise Design Alternatives—Task VI Report, dated June 23, 1998, and have been designed to provide capabilities for monitoring network performance, maximize throughput, and prevent communications outages and delays due to network failures and bottlenecks. The following descriptions differentiate these approaches:

- Alternative One is intended to achieve an acceptable level of performance improvement relative to the baseline while minimizing the backbone network infrastructure (backbone nodes, chord links, and associated equipment). While the survivability characteristics of this design alternative are considered less than optimal, there is improvement over the status quo.
- Alternative Two utilizes additional backbone network infrastructure to improve survivability characteristics, although both cost and performance are affected somewhat.
- Alternative Three maximizes survivability characteristics utilizing substantially greater backbone network infrastructure than the other alternatives.

Alternatives One, Two, and Three all constitute comprehensive enterprise network solutions, differentiated by cost, performance, and potential impact on operational users (survivability). To provide a more complete basis for decision, the possibility that none of the fully managed network alternatives would be adopted led to development of an additional alternative, defined as an incremental departure from the status quo that merely implements the recommendations of the recapacitation study (Task IV). Alternative Zero has been designated to address the incremental network changes that would be anticipated should the managed enterprise network approach be rejected. This alternative, which perpetuates the disparate telecommunications environment, may be fundamentally understood as simply “patching” current over-capacity issues. There is no provision for addressing network performance issues, or for preventing recurrence of over-capacity (due to lack of network management capabilities) in the future.

Assessment of the projected network performance, operational effects, and associated financial estimates anticipated for the various TEN alternatives was based on parametric projections over a seven year life cycle. These projections utilized conservative assumptions, representing minimal departure from the baseline, consistent with the defining attributes of the various alternatives. Performance data was established by the study, Development of Initial Enterprise Design Alternatives—Task VI Report. Other assumptions relative to the level and rate of change for the parameters that affect financial estimates are detailed in the specific explanations attached to each model (contained in Section 2 of this report). Results of the financial analysis are depicted in Table ES-1, which provides a high level summary of the life cycle costs for the four alternatives compared with the baseline costs. Section 2 of this analysis provides detailed back up for the summary information provided here.

Table ES-1. Life Cycle Cost Summary

Financial Measures	Alternative Zero Recapacitation	Alternative One Min. Redundancy	Alternative Two Med. Redundancy	Alternative Three Full Redundancy
Life Cycle cost	$366 M.	$286 M.	$293 M.	$296 M.
Savings over Baseline	$105 M. (22%)	$185 M. (39%)	$178 M. (38%)	$175 M. (37%)
Excess over lowest cost alternative	80 M. (28%)	________	7 M. (2%)	10 M. (3%)

Savings over the baseline scenario are projected to accrue from efficiencies in infrastructure and personnel, the expedited conversion of legacy modes of traffic (X.25 and dial-up) to frame relay transmission, and the reduced operational impact of outages and bottlenecks. Further quantitative analysis of financial results is contained in Section 4. These analyses, including Net Present Value and Return on Investment, confirm the relative standing of the alternatives, with significantly better financial performance projected for Alternatives One, Two, and Three than for Alternative Zero (Recapacitation). The close correspondence between these alternatives in terms of financial performance, with Alternative One (Minimum Redundancy) incrementally superior, establishes these alternatives as the finalists from which the most advantageous alternative should be selected.

In the absence of an unequivocal financial basis to determine the most advantageous alternative, the degree to which each alternative meets the project requirements should be incorporated into the decision-making process. The overriding requirement of the TEN project is to efficiently manage USDA networks, comprising the following detailed requirements:

1) Reduce duplication of telecommunications services and equipment. Optimize usage of telecommunications consistent with the business processes.
2) Improve network performance (e.g., availability, elimination of bottlenecks).
3) Provide network capabilities wherever needed at the levels required (comparable to a utility). Link network resources to business requirements based on established criteria.
4) Provide improved accountability for telecommunications decisions (e.g., quickly and easily supply data for cost/benefit analyses).
5) Migrate USDA to the post-FTS2000 environment, and provide capabilities for network services to take advantage of new tariff structures (e.g., least cost routing).
6) Provide configuration management, i.e., ensure that networks are maintained in a fully operative, fully supportable state, including Y2K compliance. Configuration items include hardware, software, and other network components (e.g., circuits).
7) Be able to readily support new telecommunications requirements, including agency application initiatives, in a proactive fashion and determine needs early in the process.
8) Ensure appropriate network security.
9) Provide a methodology for network design and implementation as a repeatable process, able to respond to growing, changing requirements in the future.

The ability of each alternative to meet these requirements has been established by the design process, culminating in the Development of Initial Enterprise Design Alternatives—Task VI Report. Each of the network design alternatives has been developed based on the ability to support the requisite functions of management, problem resolution, throughput, and availability consistent with USDA needs. The primary difference between the alternatives centers on the second requirement, to improve network performance by enhancing availability and eliminating bottlenecks. In this regard, Alternative Three provides far greater survivability than Alternatives One or Two. Given the relative proximity of these alternatives in cost, and the greater congruence between Alternative Three and the TEN network requirements, the simplified decision facing USDA is the selection between two strategies: maximizing financial performance (Alternative One) or maximizing technical goal attainment (Alternative Three).

Consistent with the preceding financial analysis, the strategy of minimizing cost within acceptable technical performance parameters is generally recognized as a reasonable risk mitigation strategy. The relative performance weakness of Alternative One in terms of outages and bottlenecks has been accounted for within the financial model. Even considering the cost impact of additional outages, Alternative One is more cost effective. In addition, the sensitivity of the analysis results to pricing variations (as described in Section 4.3) has a further favorable effect on Alternative One if prices de-escalate more slowly than projected. Given the aggressive assumptions on price decline associated with the FTS2000 follow-on contract, slower, rather than faster de-escalation seems to be the more probable variance from the projections. Under the stated assumptions, and considering likely variances from those assumptions, Alternative One is recommended as the most advantageous alternative.

Executive Summary: Chargeback Method of Analysis - Part Two

As an integral part of the Telecommunications Enterprise Network (TEN) financial analysis, alternative chargeback methods were examined. Chargeback is critical to aligning cost recovery for the TEN project with the utilization of network services consistent with USDA business practices and operational processes. Three alternatives approaches to recover the costs associated with implementing and operating a new network have been analyzed and compared.

The Static approach addresses the use of fixed operational cost drivers, not in a technical sense (e.g., kilobytes transported), but from a business standpoint. The business cost drivers would consist of items such as the number of users; user location and relative proximity to the rest of the network; and the number and types of applications that run across the network. This type of chargeback results in minimal monitoring being required in order to gather the required metrics.

A Capacity-Based approach would implement a cost recovery mechanism based on maximum bandwidth usage, which under current methods corresponds to committed information rate (CIR).

Utilization-Based approaches implement a cost recovery mechanism based on measured usage variables. The overriding premise of any utilization approach is that management traffic added to the network must be maintained within acceptable limits. The *central monitoring option* of the utilization-based approach would perform network analysis at backbone nodes. The approach would rely on the periodic gathering of statistics in order to sample the site's representative traffic. The *remote monitoring option* would require network analysis based at lower level nodes. More detailed, reliable utilization analysis would also require constant monitoring, rather than sampling.

Table ES-2 compares the level of infrastructure, effort, and transmission overhead associated with each of the approaches.

Cost Element	Static	Capacity Based	Utilization Based	
			Central Monitor	Remote Monitor
Infrastructure				
Network Infrastructure	N/A	N/A	N/A	significant
Cost Recovery Systems	simple	simple	moderate/complex	complex
Effort				
TEN Program Office	very low	low	significant	high
Contractor Personnel	N/A	N/A	none to low	significant
Transmission Overhead				
Additional Network Traffic	N/A	N/A	low (1-5%)	low (1-5%)

Table ES-2. Comparison of Cost Factors for TEN Chargeback Alternatives

Estimated cost ranges were projected for each of the referenced alternatives. The resulting estimates are depicted in Figure ES-1.

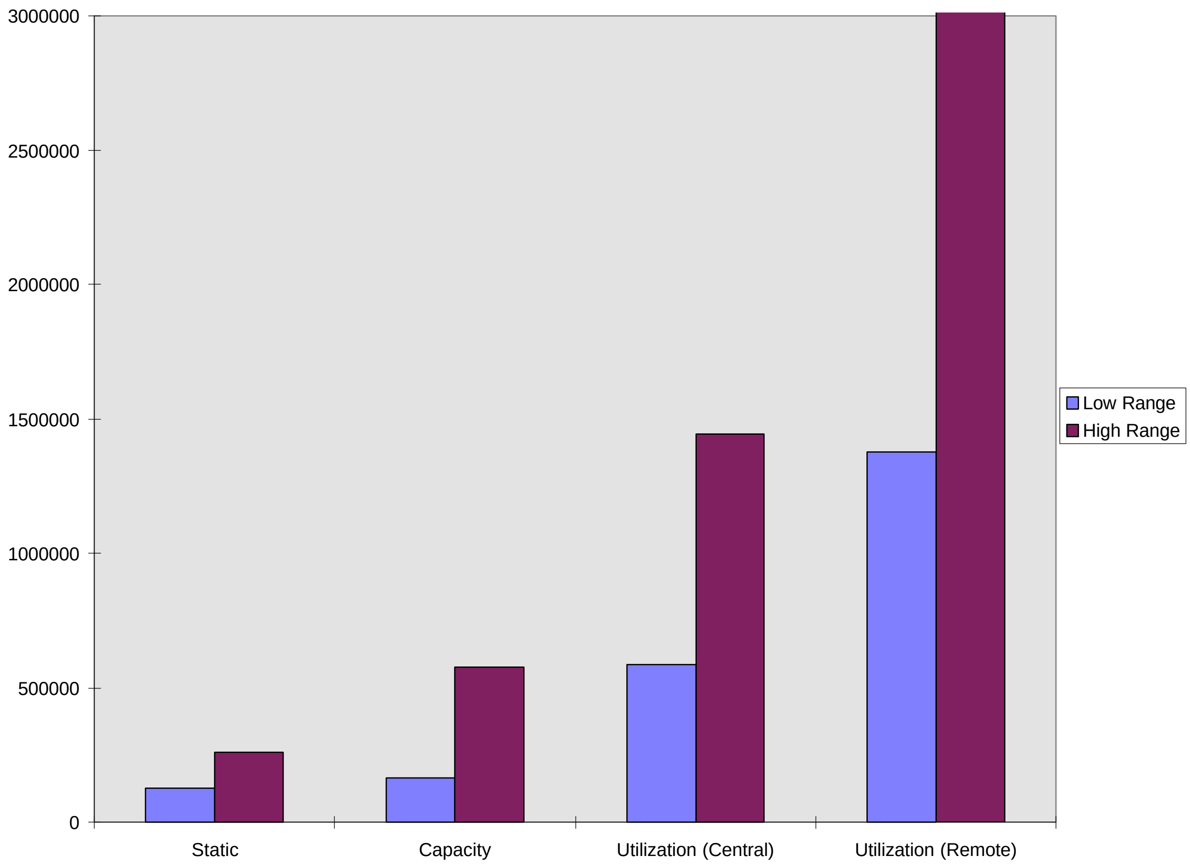

Figure ES-1. Comparative Annual Cost Estimates for TEN Chargeback Methods

A static approach provides the lowest cost method, but is least representative of USDA business processes. The capacity-based approach and the central monitoring option of utilization-based approach add the USDA business relevance to the chargeback methodology. These approaches constitute intermediate levels of cost, adding approximately .5 million to one million dollars above the estimate for the static approach.

The remote monitoring option of the utilization-based alternative achieves the most accurate representation of network usage, providing a potential governing incentive for the cost-effective use of new technologies. The additional cost associated with this method is significant, as much as one to 2.5 million dollars greater than other approaches. Within the context of the entire TEN program, however, remote monitoring utilization-based chargeback would not constitute a major addition (approximately 5 percent).

The decision that USDA faces in selecting a chargeback method for TEN services depends on the level of detail and sensitivity to utilization required to be provided to TEN program and agency operational management staffs. Better usage information, the ability to answer inquiries, and introduction of incentives for monitoring and influencing network utilization require significantly greater expenditure. If the more involved cost recovery systems required for utilization-based chargeback are determined to be necessary, the aggressive timetable projected for the TEN project requires that consideration be given to utilization of a capacity-based approach as an interim solution. Reliance on a simpler chargeback approach at the outset could avoid delays to cost recovery systems due to greater complexity of utilization-based approaches.

PART ONE

Telecommunications Enterprise Network Design

Financial Analysis of Alternatives

Task Order Request Under

GSA Schedule

PERFORMANCE ENGINEERING CORPORATION

1.0 Current Environment

This section presents the life cycle costs associated with the baseline (status quo), which assumes perpetuation of current U.S. Department of Agriculture (USDA) networks and other telecommunications products and services. Under this scenario, USDA would not initiate a Telecommunications Enterprise Network (TEN), and would require the *ad hoc* augmentation of current solutions in response to growth and evolution of user demand, as well as necessary maintenance, both for cyclical replacement of aging hardware/software and for one-time requirements. Costs include system-related capital costs, personnel costs, as well as other costs related to mission operations to include transmission services and network outages.

1.1 Basis of Current Cost

To provide a financial basis for management decisions on the TEN project, current costs must be established to support comparisons between current and future ways of providing network products and services. These comparisons support identification and selection of the alternative that would result in the most advantageous combination of minimizing costs and maximizing benefits. In addition to costs directly associated with providing network capability, such as circuit, router, and toll charges, other operational costs, such as personnel responsible for maintaining network performance, and providing routine maintenance, are also included in the baseline.

The estimation of network-related infrastructure, operations, and maintenance is the major focus of the baseline analysis. Comparison of the baseline with proposed alternatives provides the means of establishing the difference between the projected future costs and benefits of each alternative and current operations, assuming only minimal changes. The focus of this analysis serves to highlight network-related costs that vary between baseline and alternatives, while certain categories of telecommunications costs, such as those related to FTS voice, local exchange carrier, and other commercial carrier—although large in absolute terms—are not differentiated between the baseline and the alternatives, and therefore do not affect the selection of the most advantageous alternative.

1.1.1 General Assumptions

The following assumptions are global and apply to the baseline (as well as any of the TEN alternatives).

- The life cycle period is 7 years. This period is consistent with acquisition/transition timeframe projected to end in April 2000. The remainder of Fiscal Year (FY) 2000 and the following five years' operation constitutes the relevant decision horizon.
- Escalation and discount rates are consistent with Office of Management and Budget (OMB) Circular A–94, "Guidelines and Discount Rates for

Benefit-Cost Analysis of Federal Programs." Escalation rates are projected at 3% for personnel, contracted services, facility and related expenses. Hardware and software costs are projected using zero escalation. Circuit, access, line speed and related toll charges are covered by separate assumptions for FTS2000 and its successor contract.

- Operational costs for personnel include salaries and benefits, office space, furniture and equipment, office automation, telephone, training, and supplies and materials.
- Overhead rates, facilities rates, and other personnel-related factors are based on information obtained from USDA and other federal agencies.
- Y2K upgrades are projected to be completed by 2nd quarter FY99 in conjunction with USDA guidance. This timeframe coincides with the acquisition phase of TEN Alternatives, which results in a prerequisite condition of Y2K compliance for the relevant decision period.

1.1.2 Current Operations

Current costs for many elements of the baseline have been determined based on the discovery process of monitoring network traffic over a sufficient period to capture representative patterns of utilization, supplemented by survey of agency network managers. Where information on current operations was unavailable or incomplete, parametric estimates were employed to provide a more complete basis for comparison. The major elements that characterize the current operations are described in the paragraphs that follow.

Infrastructure assets comprised of circuits and hardware, which have already been installed, are sunk costs and, therefore, are not included in the cost of current operations. Circuits, as identified in the USDA TEN Task I report, vary greatly in terms of size and type as shown in Table 1. Based on the circuit quantities shown in Table 1, an almost direct one for one correlation between the circuit quantities and the router quantities (927 identified in the TEN analysis) can be made. To maintain current operational capability, however, cyclical replacement of outdated or non-functional hardware is expected to occur at regular intervals over the period of analysis. Hardware to be replaced includes routers, which are the primary component of the USDA wide area networks (WAN), Front End Processors for Systems Network Architecture (SNA), and multiplexers related to shared voice and data circuits where these quantities were able to be determined explicitly and where a cost element was able to be applied. . The estimated hardware costs associated with these hardware elements are depicted in Table 2, from which cyclical replacement costs will be projected.

Table 1 Estimated Circuit Infrastructure of Current USDA Network Asset

Agency	19K	28K	56K	64K	112K	128K	192K	256K	512K	768K	960K	1024K	1029K	1033K	1051K	1152K	1408K	1536K	E1	T1	Total
AARC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
AMS	0	0	0	47	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	8	**56**
APHIS	1	0	21	7	0	18	0	7	0	3	0	1	0	0	0	0	0	2	0	17	**77**
ARS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	**29**
BCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
CSREES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**
DAMS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
ERS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**
FAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
FNS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	**5**
FS	0	3	27	25	1	25	0	19	16	32	7	3	1	1	1	4	2	33	1	274	**475**
FSA	0	0	1	13	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5	**20**
FSIS	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
GIPSA	0	0	0	11	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	**14**
NAD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
NAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
NASS	0	0	0	0	0	13	23	0	0	0	0	0	0	0	0	0	0	1	0	9	**46**
NRCS	0	0	18	34	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	13	**67**
NSIIC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
OALJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
OBPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
OC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
OCE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**
OCFO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	**2**
OCIO	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	**25**
OES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
OGC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
OO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	**2**
OSDBU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
PACC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
RD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	79	**79**
RMA	0	0	1	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	**17**
SEC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SCA*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
TOTAL	**1**	**3**	**70**	**151**	**1**	**60**	**23**	**27**	**17**	**35**	**7**	**4**	**1**	**1**	**1**	**4**	**2**	**36**	**1**	**473**	**918**

*** SCA represents Service Center Agencies**

Circuit Groups	0-64K	65-128K	129-256K	257-512K	513-768K	769-1024K	1025-1536K	E1	T1	TOTAL
Original	225	61	50	17	35	11	45	1	473	918
Task VI Adjustment	120	36	10	7	14	0	18	0	-127	78
Total	**345**	**97**	**60**	**24**	**49**	**11**	**63**	**1**	**346**	**996**

Table 2 Total Hardware Costs by Agency

Agency	Router Costs	MUX Costs*	SNA Network**	Total Costs
AARC	$0			$0
AMS	$449,452			$449,452
APHIS	$617,996			$617,996
ARS	$232,752			$232,752
BCA	$0			$0
CSREES	$8,026			$8,026
DAMS	$0			$0
ERS	$8,026			$8,026
FAS	$0			$0
FNS	$40,130			$40,130
FS	$3,812,315	$1,238,000		$5,050,315
FSA	$160,519	$84,000		$244,519
FSIS	$8,026			$8,026
GIPSA	$112,363			$112,363
NAD	$0			$0
NAL	$0			$0
NASS	$369,193			$369,193
NRCS	$537,737			$537,737
NSIIC	$0			$0
OALJ	$0			$0
OBPA	$0			$0
OC	$0			$0
OCE	$8,026			$8,026
OCFO	$16,052			$16,052
OCIO	$200,648	$50,000	$240,000	$490,648
OES	$0			$0
OGC	$0			$0
OO	$16,052			$16,052
OSDBU	$0			$0
PACC	$0			$0
RD	$634,048			$634,048
RMA	$136,441			$136,441
SEC	$0			$0
SCA***	$2,400,000			$2,400,000
TOTAL	**$9,767,800**	**$1,372,000**	**$240,000**	**$11,379,800**

*** Costs include hardware for Kansas City and Washington Service Center**
**** Costs include maintenance for two front-end processors per site - NFC and NITC**
***** Costs include 600 routers for Service Center Agencies (SCA) transition**

Personnel-based costs address the costs associated with personnel involved in the operation and maintenance of current USDA networks. The most identifiable and relevant personnel costs are associated with personnel responsible for central maintenance of USDA networks. Table 3 depicts the estimates of current central maintenance of the data networks operated by USDA at the department level, and by its agencies. Required multitasking between tasks including voice, video, and other communications issues are expected to account for a substantial minority of the effort of network staff. The staff count shown in Table 3 has been allocated to data network maintenance at a proportion of 60% to account for the involvement of network maintenance personnel in other tasks.

Table 3 Estimated Current Central Maintenance of USDA Networks

Organization	[1] Network Complexity	[2] Support Staff	Special Requirements	[3] Staff Count
Departmental Internet Access	medium (includes 2 service centers)	Network manager, plus For each center: network engineer network technician	network management software - Spectrum	5
Forest Service	high: central mgmt + 12 regional WANs	network manager 2 network engineers 3 network technicians 12 regional technicians	network management software - OpenView	18
APHIS	medium (includes 2 service centers)	For each center: network manager network engineer 2 network technicians	network management software - OpenView	8
SNA:National Information Technology Center and National Finance Center	high, includes front end processor and VTAM table maintenance	For each location: network manager systems programmer network engineer, & 1 network technician for each of 5 shifts	7 X 24 operation	[4] 16
AMS	low to medium	network manager network engineer network technician		3
ARS	low to medium	network manager network engineer network technician	maintain link with Dept. Internet Access network	3
Food, Nutrition & Consumer Services	low to medium	network manager network engineer network technician		3
Service Center Agencies: RD, NRSC & RHA	medium	network manager network engineer 2 network technicians	maintain dial-up capability for use by more than 4000 sites	4
FSIS	medium	network manager network engineer 2 network technicians		4
GIPSA	low to medium	network manager network engineer network technician	maintain hub into Washington for link into AMS network	3
NASS	high (state offices hub into backbone)	network manager 2 network engineers 3 network technicians	network management software - Spectrum	6
RMA	medium	network manager network engineer 2 network technicians	network management software - Spectrum	4
Total USDA		14 network managers 2 systems programmer 17 network engineers 44 network technicians	7 site licenses for network management software: Spectrum, OpenView	77

[1] Complexity is a function of number of nodes, degree of central management, & software
[2] Support staff based on classification of network (small, medium, large)
[3] Staff count estimated based on a single shift of support staff
[4] Staff count estimated based on 5 shifts of support staff to account for (7 X 24) availability

Network staff does not include tier-one (direct user) help desk support. Current USDA support staff whose primary role is LAN maintenance has been included as an additional component of network maintenance due to their dual responsibility for WAN maintenance, primarily for special router maintenance or installation. Because the nature of this WAN support is not the primary duty assignment, allocation of proportional effort by classes of staff will be more representative than identification of full time assigned staff, that perform specific functions.

Program management under the baseline scenario is not characterized by the consolidated project management of the TEN project. In consideration of the volume of staff effort and contract value being managed under separate efforts, the requirement exists for program management of diverse efforts, which, although diffuse, must be accounted for to ensure equivalent comparisons of budgetary, contractual, and supervisory functions between baseline and alternative scenarios. Because of the highly decentralized and fragmented nature of program activities, a proportional allocation of acquisition, personnel, and other operational expenditures is assigned to account for program management effort of current telecommunications-related products and services.

Other Costs related to mission operations include, but is not limited to, Transmission costs and Network Outages. Transmission costs address the costs associated with network traffic. Transmission costs that are within the scope of analysis include the following components:

- Costs for access and line speed for lines associated with routers on Frame Relay traffic. Part of this cost includes a Permanent Virtual Circuit (PVC) cost associated with a logical frame relay committed rate or burst rate. This cost was also identified in the TEN Task VI Report
- Costs for packets associated with X.25 traffic
- Costs for Inter-LATA tolls associated with access of central network capability (located at National Information Technology Center in Kansas City) from field offices (primarily Service Center Agencies).

Table 4 depicts current infrastructure transmission cost estimates, from which cyclical replacement costs will be projected.

Table 4 Estimated Transmission Costs of Current USDA Networks

Agency	Circuit Costs	X.25 Costs	Dial-up Costs	Total Costs
AARC	$0			$0
AMS	$396,612	$22,166		$418,778
APHIS	$603,564	$631,007		$1,234,571
ARS	$264,132	$224,969		$489,101
BCA	$0			$0
CSREES	$9,108	$3,428		$12,536
DAMS	$0			$0
ERS	$9,108			$9,108
FAS	$0	$2,188		$2,188
FNS	$45,540			$45,540
FS	$3,987,528	$1,750,696		$5,738,224
FSA	$147,564	$678,468		$826,032
FSIS	$6,768	$1,377,797		$1,384,565
GIPSA	$104,952	$6,475		$111,427
NAD	$0			$0
NAL	$0	$534		$534
NASS	$451,320	$8,633		$459,953
NRCS	$485,748	$152,991		$638,739
NSIIC	$0			$0
OALJ	$0			$0
OBPA	$0			$0
OC	$0			$0
OCE	$9,108			$9,108
OCFO	$18,216	$17,267		$35,483
OCIO	$220,788	$53,032		$273,820
OES	$0			$0
OGC	$0	$73		$73
OO	$18,216	$6		$18,222
OSDBU	$0			$0
PACC	$0			$0
RD	$719,532	$674,442		$1,393,974
RMA	$122,580	$26,047		$148,627
SEC	$0	$17		$17
SCA*	$0		$4,149,721	$4,149,721
Unidentified	$263,724			$263,724
PVC	$280,260			$280,260
TOTAL	**$8,164,368**	**$5,630,234**	**$4,149,721**	**$17,944,323**

*SCA Represents Service Center Agencies

In addition to transmission costs, one other major category of the Other Costs grouping, as shown in Table 5, is network outage costs. Network outage costs were derived from the total number of critical messages that was estimated for each type of network disaster defined in the study. To arrive at these totals, a sampling of USDA network traffic data was examined to determine the total per day number of messages (critical and non-critical) that is affected, on average, by each type of network disaster. A workday factor was applied to this 24-hour total to arrive at the total number of all messages affected in one workday. A workday is defined as a 24 hour period starting at 10:00AM and ending the next day at 10:00AM as analyzed in the USDA Discovery Model. For catastrophic events, major outages and minor outages, the resulting workday message total was then multiplied by a 10% critical message factor to determine the total number of critical messages that would require immediate delivery via other communication channels. For a bottleneck event, the critical message factor is 5%. Table 6 depicts the parameters of operational effects due to outages on which the analysis has been based.

Augmentation of current network traffic is anticipated by the introduction of additional mission-related applications. Although core operational and administrative applications do not account for the preponderance of current traffic, expected availability of enhanced applications in the outyears of the analysis period is expected to increase the criticality of network messages. Accordingly, the assumed level of critical messages has been projected to increase by 5% per year.

Table 5 Estimated Effect of Network Outages

TYPE	DESCRIPTION	AVG OUTAGE TIME (sample data 2/95-6/98)	CRITICAL MESSAGES AFFECTED*
Catastrophic	A network event that shuts down normal business operations and causes a departmental-wide disruption of services. This type of outage is an unusual occurrence that happens only once every two or three years.	24 Hrs	[1] 330,000
Major outage	A network failure that results in a regional or agency-wide disruption of service. This type of outage usually lasts less than 24 hours and occurs about three times a year.	8 Hrs	[2] 15,000
Bottleneck	Network overloads have similar characteristics and frequencies as major outages, however, only service is degraded rather than service lost.	12 hrs	[3] 11,250
Minor outage	An interruption of network operations that affects an isolated set of users. These outages, due to local nature of effect, have not been logged. An estimate of frequency is between 100 and 500 minor outages per year.	3 Hrs	[4] 25

[1] Estimated daily message traffic = 3,300,000 (10% of which estimated to be critical). Duration of the single logged catastrophic event was an entire day.
[2] Estimated daily message traffic = 225,000 * (8 hours duration / 12 hours peak activity in a region)
= 225,000 * .67 = 150,000 messages affected (10% of which estimated to be critical)
[3] Estimated daily message traffic = 225,000 * (12 hours duration / 12 hours peak activity in a region)
= 225,000 messages affected (5% of which estimated to require expedited handling)
[4] Estimated daily message traffic = 660 * (3 hours duration / 8 hours peak activity in a single office)
= 250 messages affected (10% of which estimated to require expedited handling)

The cost effect has been based on the number of critical messages, estimating 15 minutes per message to use alternate means (e.g., phone, fax) to determine message was not received, to transmit the information, and confirm receipt. Representative labor category of GS-10, step 5, has been used to generate salary effect of non-productive effort due to network outages and bottlenecks.

1.2 Baseline Projections

Telecommunications workload may be expected to increase during the period of analysis due to increasing importance of inter-office communication, increasing capabilities of and comfort with communications-based packages, such as electronic mail, and the prevalence of Internet-based applications. Historical growth rates of the Internet have been used to project future increases in telecom traffic for USDA. PEC examined data for the growth in the number of hosts, networks, domains, and sites on the Internet to pick a possible proxy for USDA telecom traffic growth. All of these variables showed exponential growth.

Growth in Internet hosts was selected as the most reasonable proxy for USDA telecom traffic growth. PEC was able to fit an exponential curve to the historical data for the number of Internet hosts. This curve had an R^2 of .998. Using this curve, USDA telecom traffic would be expected to increase by 7770% by 2005. This is equal to an annual growth rate of 260% over the next five years. Clearly, this is an unreasonable projection.

Telecommunication traffic is expected to continue to grow at high rates, but not the exponential rates of the past. PEC used exponential smoothing with trend adjustment to reexamine the historical growth rates of Internet hosts. Exponential smoothing uses the following formula to forecast projected growth:

$$F_t = \alpha A_{t-1} + \alpha(1 - \alpha)A_{t-2} + \alpha(1 - \alpha)^2 A_{t-3} + ... + \alpha(1 - \alpha)^n A_{t-n}$$

where

F_t = forecast for period t

α = smoothing constant chosen by forecaster with value between 0 and 1

A_{t-1} = previous period's demand

This forecast was then adjusted for trend lags.

$FIT_t = F_t + T_t$

$T_t = (1 - \beta)T_{t-1} + \beta(F_t - F_{t-1})$

where

T_t = smoothed trend for period t

T_{t-1} = smoothed trend for previous period

β = trend smoothing constant chosen by forecaster with value 0 - 1

F_t = simple exponential smoothed forecast for period t

F_{t-1} = forecast for previous period

Using exponential smoothing with trend adjustment, telecommunications traffic at USDA is projected to grow approximately five-fold by 2005. This is equivalent to an approximately 30% annual growth rate. This growth will be more intensive in earlier years and will tend to taper off in the out years. This reflects the decreased marginal impact of acquisition of telecommunications technology as more USDA staff become connected to the World Wide Web. The chart below gives annual growth rates.

Year	Annual Growth Rate
1999	*1.854
2000	1.337
2001	1.252
2002	1.201
2003	1.168
2004	1.144
2005	1.126

* The first year growth factor has been increased from 1.509 to 1.854 to reflect the greater than one year timeframe projected to elapse between the discovery process and Year One of the analysis period.

Pricing of post-FTS2000 requires observation of trends and projection of future pricing, which will be determined by both market and acquisition-related factors. The overall increase in demand is projected to drive a compensating drop in price. The pattern associated with this increasing economy of scale cost structure is that costs will be distributed based on direct relationship to total capacity, necessitating price points based on access. Based on competitive acquisition and long-run decline of marginal cost of providing backbone circuitry, economies of scale experienced by telecommunications vendors will most probably be reflected in the cost of access associated with routers on the Frame Relay circuits. The projection for the baseline model is that the increase in traffic will be compensated by an inversely proportional decrease in the price of bandwidth based access costs.

Fluctuating traffic, such as dial-up access, may be projected to continue to decline, however, would not be projected to be priced advantageously relative to dedicated Frame Relay access. The incentive for telecommunications vendors under FTS2001 will be to encourage more predictable bandwidth requirements, and to exact a price premium for fluctuating bandwidth requirements, because these may impose network bottlenecks, with associated traffic delays, or may require the temporary acquisition of additional bandwidth from resellers, the costs of which would be passed along to the government. Although the pattern of telecommunications price projections is declining for all types of access, the rate of decline is projected to be more advantageous for Frame-Relay-based traffic than for dial-up access.

Table 6 depicts the baseline estimate of current operational costs that are relevant to the TEN project analysis of alternatives.

Table 6 Projected Life Cycle Costs

Baseline Life-Cycle Costs	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Total
1. Capital Costs								
a. H/W Acquisition	2,275,960	2,275,960	2,275,960	2,275,960	2,275,960	2,275,960	2,275,960	15,931,720
b. S/W Acquisition	0	142,000	0	0	0	142,000	0	284,000
c. Installation, Config. & Testing	101,529	132,975	107,712	110,944	114,272	146,100	121,231	834,763
Subtotal - Capital	2,377,489	2,550,935	2,383,672	2,386,904	2,390,232	2,564,060	2,397,191	17,050,483
2. Personnel Costs								
a. Program Mgmt.	773,789	802,109	813,983	834,988	856,624	887,429	901,862	5,870,783
b. Network Mgmt., Maint., & Security	7,198,168	7,414,113	7,636,536	7,865,632	8,101,601	8,344,649	8,594,989	55,155,687
c. Network Architecture/Design	3,991,863	4,111,619	4,234,967	4,362,016	4,492,877	4,627,663	4,766,493	30,587,498
d. Office, Furniture, & non-OA Equip.	791,040	814,771	839,214	864,391	890,322	917,032	944,543	6,061,314
e. OA, Telephone, Supplies, and Materials	203,034	209,125	215,398	221,860	228,516	235,372	242,433	1,555,737
f. Training	197,760	203,693	209,804	216,098	222,581	229,258	236,136	1,515,329
Subtotal - Personnel	13,155,653	13,555,429	13,949,902	14,364,985	14,792,521	15,241,403	15,686,455	100,746,348
3. Other Costs								
a. Transmission	20,740,284	22,147,733	23,204,036	23,963,413	24,482,909	24,798,611	24,945,761	164,282,749
b. H/W and S/W Maintenance	1,152,180	1,152,180	1,152,180	1,152,180	1,152,180	1,152,180	1,152,180	8,065,260
c. Contracted Services	7,441,050	7,664,281	7,894,210	8,131,036	8,374,967	8,626,216	8,885,002	57,016,761
d. Network Outage Operational Impacts	2,733,743	5,646,997	9,709,522	15,013,713	21,674,517	29,796,103	39,493,628	124,068,224
Subtotal - Other Costs	32,067,257	36,611,192	41,959,948	48,260,342	55,684,573	64,373,111	74,476,572	353,432,994
Total	47,600,399	52,717,556	58,293,522	65,012,231	72,867,325	82,178,573	92,560,218	471,229,825

The baseline costs are presented in the following categories:

1. Capital Costs: costs represent additional infrastructure acquisition or upgrade, including hardware and software.

1.a Hardware: Hardware costs are based on the cyclical replacement of the router inventory using a conservative cycle of complete replacement within five years. This equates to purchase of 20% of the current inventory value annually (assuming a zero escalation rate for technology infrastructure items). Also, includes additional hardware associated with addition of some Forest Service and Service Center Agencies (SCAs) nodes to agency networks over the period of analysis.

1.b Software: Software costs are based on periodic technical refreshment of the monitoring capability for network activity, which is currently contained within the separately managed networks, e.g. Spectrum and OpenView. Major technology refreshment is anticipated to occur at intervals of four years, represented by the replacement of network monitoring software in Year 2 and Year 6 of the analysis. Router software is considered to be bundled, and included within the hardware acquisition category.

1.c Installation and Testing: installation and testing costs of hardware and software is classified as a capital cost. Installation and testing of hardware acquired for cyclical replacement or for the addition of new offices is estimated to require one person day of effort by current LAN maintenance staff allocated at average salaries for USDA personnel series 0334 and 0391.

2. Personnel Costs: salary and overhead costs for personnel involved in the operation and maintenance of current USDA networks and any costs associated with those personnel (such as office space, supplies and materials, and furniture).

2.a Program Management: costs of managing the staff effort, budgets, and contracts under separate network projects. Program management estimates are based on a 5% allocation of acquisition, personnel, and related operational costs to represent highly distributed budgeting, contract management, and supervisory functions.

2.b Network Management, Maintenance and Security: costs related to operation of current networks. In addition to personnel responsible for central maintenance of USDA networks (described in Section 1.1.2 Current Operations), network management efforts are also estimated for support staff whose primary role is Local Area Network (LAN) maintenance, which reflects primarily special router maintenance or installation. Salaries for personnel are based on average costs for applicable USDA series 0334, Computer Specialist, and 0391, Telecommunications Specialist.

2.c Network Architecture/Design: costs related to policy and oversight of current networks. Includes positions within the Associate Chief Information Officer - Telecommunications Services and Operations (excluding personnel responsible for telephone), as well as positions within the Office of the CIO that are in the 0391 series, Telecommunications Specialist.

2.d Office, Furniture & Equipment: office space costs for operational personnel whose primary assignment involves network management or design. Support staff whose primary role is Local Area Network (LAN) maintenance, but who have part-time responsibilities for special router maintenance or installation are not included in the allocation for facilities-related expenses. Estimates are based on 125 sq. ft./person @ $3/sq.ft. /month for office, and $1/sq.ft. /month for furniture and non-ADP equipment. Costs are based on representative federal agency rates.

2.e Office Automation, Telephone, Supplies and Materials: costs for workstation, file, print, and communication services (capital costs only), telephone usage, supplies, materials and miscellaneous items. Support staff whose primary role is Local Area Network (LAN) maintenance, but who have part-time responsibilities for special router maintenance or installation are not included in the allocation for Office Automation-related expenses. Estimates are based on $1,540/person/yr, including $600 for workstation ($1800 purchase every 3 years), $500 for LAN services, $240 for telephone, $150 for supplies and materials, and $50 for miscellaneous operational expense items.

2.f Training: costs for technical training of telecommunications personnel. Support staff whose primary role is Local Area Network (LAN) maintenance, but who have part-time responsibilities for special router maintenance or installation are not included in the allocation for Training-related expenses. Estimates are based on 1 vendor-provided two-day technical class, estimated at $1500 per class.

3. Other Costs: include network-related costs in addition to capital and personnel-related costs.

3.a Transmission: costs include bandwidth-based Frame Relay costs, packet-based X.25 costs, and duration-based dial-up traffic. Frame Relay traffic will be expected to grow by greater than 400%, (due to increasing use of Internet) coupled with a compensating decrease in rate, resulting in negligible change in costs over the analysis period. Dial-up traffic will be expected to experience the greater than 400% growth, however, the price decline is expected to mirror current incremental decreases of 10% annually. X.25 traffic is not expected to experience significant change in volume or price, based on historical patterns.

3.b Maintenance: costs of hardware and software maintenance agreements. These costs are based on 10% of installed base, which is consistent with prevalent arrangements for maintenance agreements.

3.c Contracted Services: costs for telecommunications-related engineering and consulting contracts. Costs are based on contracts for telecommunications-related ADP services and facilities management for the most recent year.

3.d Network Outages Operational Effects: costs associated with the potential of losing messages as described in Section 1.1.2 of this report.

As a result of the analysis described in Section 1.1 and the projections defined in Section 1.2, an overall cost of the USDA Baseline Network has been calculated as depicted in Table 6, given that the baseline network remains through the projected life. Using several major categories of Table 6, an overall structure of the allocation of costs between these major categories can be represented as shown in Figure 1.

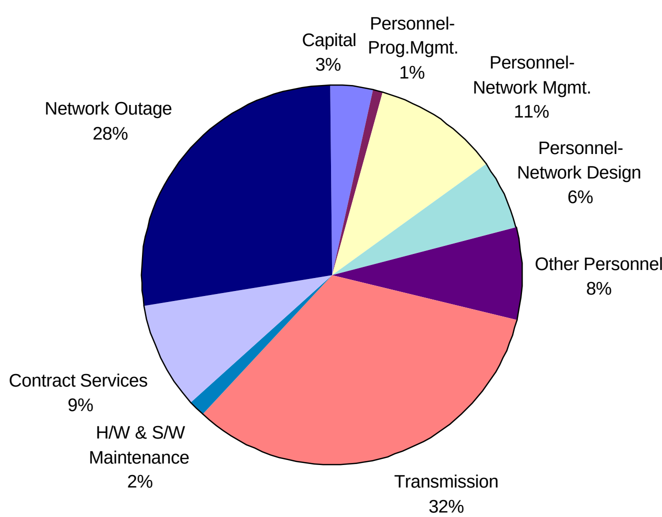

Figure 1 High-Level Cost Composition of Baseline

2.0 Cost Analysis of Alternatives

This section presents the life cycle costs associated with the alternative solutions for addressing the telecommunications network requirements of the U.S. Department of Agriculture (USDA). These solutions address to varying extents the growth and evolution of user demand, changes within the telecommunications environment (exemplified by the transition from FTS2000 to the follow-on contract), as well as the needed responsiveness to both short-term performance issues, such as network interruptions or bottlenecks, and longer-term issues, such as changing requirements because of fielding new mission applications. This cost analysis addresses system-related capital costs, operations and maintenance costs, such as Government personnel and contracted services, as well as mission-related operational costs due to outages and bottlenecks.

2.1 Identification of Alternatives

Should the USDA proceed with implementation of the Telecommunications Enterprise Network (TEN), three alternative approaches have been identified, which are described in the document entitled Development of Initial Enterprise Design Alternatives—Task VI Report, dated June 23, 1998. These alternatives are intended to provide capabilities for monitoring network performance, maximizing throughput, and preventing communications outages and delays due to network failures and bottlenecks. The following descriptions differentiate these approaches:

- Alternative One is intended to achieve an acceptable level of performance improvement relative to the baseline while minimizing the backbone network infrastructure (backbone nodes, chord links, and associated equipment). While the survivability characteristics of this design alternative are considered less than optimal, there is improvement over the status quo.
- Alternative Two utilizes additional backbone network infrastructure to improve survivability characteristics, although both cost and performance are affected somewhat.
- Alternative Three maximizes survivability characteristics utilizing substantially greater backbone network infrastructure than the other alternatives.

The preceding design alternatives would implement a managed enterprise network, consistent with Telecommunications Network Stabilization and Migration Program (TNSMP) objectives. To address the outcomes resulting from failure to adopt any of these alternatives, an incremental departure from the status quo that implements the recommendations of the recapacitation study (Task IV) has been added. This alternative poses minimal modification to the baseline scenario, and, for that reason, is addressed initially to take advantage of the continuity with the description of the baseline provided in the preceding sections. Alternative Zero, Recapacitation, is described in the next section, followed by the designed TEN alternatives in the subsequent sections.

2.2 Alternative Zero—Recapacitation

Alternatives One, Two, and Three all constitute comprehensive enterprise network solutions, differentiated by cost, performance, and potential impact on operational users (survivability). To provide a more complete basis for decision, the possibility that none of the fully managed network alternatives would be adopted led to development of an additional alternative. Alternative Zero has been designated to address the incremental network changes that would be anticipated should the managed enterprise network approach be rejected. This alternative, which perpetuates the disparate telecommunications environment, may be fundamentally understood as simply "patching" current over-capacity. There is no provision for addressing network performance issues, or for preventing recurrence of over-capacity (due to lack of network management capabilities) in the future.

The following major changes to the baseline cost would be anticipated if incremental modifications of current disparate networks were undertaken based on rejection of a comprehensive managed enterprise network approach:

- Personnel-related: Reducing the deleterious effects of network outages experienced in the current environment would require greater focus on management of the disparate networks. Because network interoperability is not addressed by recapacitation, the only means of improving network management is increased staffing to allow the positions identified under the baseline scenario to be fully dedicated to data network operations, rather than multi-tasking between voice, video, and other communications issues, as is the case at present. Slight efficiencies with regard to local area network (LAN) maintenance staff would be anticipated under Alternative Zero due to incrementally improved network monitoring and quicker diagnostic response to network performance anomalies. The increased staff would also be expected to implement the transition from FTS2000 to the follow-on contract.
- Transmission: Recapacitation of current networks is projected to produce approximately 23% savings relative to the baseline scenario based on immediate implementation of the findings of the recapacitation study (Task IV). These savings are associated with initial years of the life cycle period, and would be expected to dissipate during the outyears of the analysis period due to reintroduction of excess capacity that is intrinsic absent the capability for proactive network management. Additional cost efficiencies over the baseline scenario would be expected due to transition of X.25 and dial-up traffic to Frame Relay. Absence of comprehensive planning and design capabilities would inhibit

completion of the transition to Frame Relay until the outyears of the analysis period.

- Operational Effects of Network Outages: Incremental improvements in the duration of outages and bottlenecks can be anticipated due to better reaction to network anomalies given the full staffing of network management positions under this alternative. No improvement would be expected in the frequency or degree of outages and bottlenecks because the fundamental network structure is assumed to be unchanged in Alternative Zero.

Estimated costs for Alternatives Zero are depicted in Table 7. Descriptions of the basis of estimate are contained in the subsequent paragraphs. Costs have been classified into the same categories as the baseline.

Table 7 Projected Alternative Zero Life Cycle Costs

Alternative 0 - Recapacitation	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Total
A. ONE-TIME IMPLEMENTATION COSTS								
1. Capital Costs								
a. H/W Acquisition	2,275,960	2,275,960	2,275,960	2,275,960	2,275,960	2,275,960	2,275,960	15,931,720
b. S/W Acquisition	0	142,000	0	0	0	142,000	0	284,000
c. Installation, Config. & Testing	101,529	132,975	107,712	110,944	114,272	146,100	121,231	834,763
Subtotal - Capital	2,377,489	2,550,935	2,383,672	2,386,904	2,390,232	2,564,060	2,397,191	17,050,483
2. Personnel Costs								
a. Program Mgmt.	773,789	793,623	796,756	808,759	821,122	842,376	846,972	5,683,397
b. Network Mgmt., Maint., & Security	7,198,168	8,765,412	9,028,375	9,299,226	9,578,203	9,865,549	10,161,515	63,896,447
c. Network Architecture/Design	3,991,863	4,111,619	4,234,967	4,362,016	4,492,877	4,627,663	4,766,493	30,587,498
d. Office, Furniture, & non-OA Equip.	791,040	814,771	839,214	864,391	890,322	917,032	944,543	6,061,314
e. OA, Telephone, Supplies, and Materials	203,034	209,125	215,398	221,860	228,516	235,372	242,433	1,555,737
f. Training	197,760	203,693	209,804	216,098	222,581	229,258	236,136	1,515,329
Subtotal - Personnel	13,155,653	14,898,243	15,324,514	15,772,350	16,233,621	16,717,250	17,198,092	109,299,723
3. Other Costs								
a. Transmission	18,857,266	18,359,853	17,194,403	15,548,761	13,579,326	13,705,619	13,764,479	111,009,708
b. H/W and S/W Maintenance	1,152,180	1,152,180	1,152,180	1,152,180	1,152,180	1,152,180	1,152,180	8,065,260
c. Contracted Services	7,441,050	7,664,281	7,894,210	8,131,036	8,374,967	8,626,216	8,885,002	57,016,761
d. Network Outage Operational Impacts	2,733,743	2,823,499	4,854,761	7,506,857	10,837,259	14,898,052	19,746,814	63,400,984
Subtotal - Other Costs	30,184,239	29,999,813	31,095,554	32,338,833	33,943,732	38,382,067	43,548,476	239,492,713
Total	45,717,381	47,448,991	48,803,741	50,498,087	52,567,584	57,663,377	63,143,759	365,842,919

The costs for Alternative Zero are presented in the following categories. Only categories for which costs are different from the baseline have been described in detail:

1. Capital Costs: costs represent additional infrastructure acquisition or upgrade, including hardware and software.

1.a Hardware: Hardware costs for the cyclical replacement of the routers, multiplexers, and front-end processors are based on the same assumptions of complete replacement over a 5 year period as in the baseline scenario (due to continued agency-level asset management).

1.b Software: Software costs are the same as in the baseline scenario due to continued agency-level asset management.

Y2K software upgrades are projected to be completed by 2nd quarter FY99 in conjunction with USDA guidance. This timeframe coincides with the acquisition phase of TEN alternatives, which results in a prerequisite condition of Y2K-compliance for the relevant decision period.

1.c Installation and Testing: Installation and testing costs are the same as in the baseline scenario for the existing installed router base.

2. Personnel Costs: salary and overhead costs for personnel involved in the operation and maintenance of current USDA networks and any costs associated with those personnel (such as office space, supplies and materials, and furniture).

2.a Program Management: costs of managing the staff effort, budgets, and contracts under the various project offices responsible for management of the current disparate networks. Program management estimates utilize the same basis (a 5% allocation of acquisition, personnel, and related operational costs) as the baseline scenario. The program management allocation results in a larger estimate for than for the baseline scenario because of the dedicated, rather than proportional assignment of agency network engineers to data network management (reference 2.b, below).

2.b Network Management, Security, and Maintenance: costs related to operation of current networks. The estimated number of positions allocated to maintenance of agency networks is the same as under the baseline scenario. Because of increased network management emphasis, however, these positions will be assumed to be fully allocated to data network management, rather than multi-tasked between data, voice, video, and other areas (e.g., Y2K troubleshooting). Assignment of fully dedicated positions to data network management from the 60% allocation estimated under the baseline scenario results in a 67% increase in Full Time Equivalent (FTE) effort allocated to central network management.

Improved network management of routers due to central management would result in an offsetting reduction of effort estimated for support staff whose primary role is LAN maintenance. The enhanced monitoring, diagnosis, and resolution capabilities should reduce the involvement of LAN maintenance personnel incrementally. Reducing the estimated level of local WAN maintenance activity by 25% reflects the decreased responsibility for diagnosis and resolution, while continuing special router maintenance and/or installation (e.g., due to repair or replacement). Salaries for personnel are based on average costs for applicable USDA series 0334, Computer Specialist, and 0391, Telecommunications Specialist.

2.c Network Architecture/Design: costs related to policy and oversight of current networks. These are estimated at the same levels as in the baseline scenario.

2.d Office, Furniture & Equipment: office space costs for operational personnel whose primary assignment involves network management or design. Proportional costs relative to the number of personnel are consistent with the baseline scenario.

2.e Office Automation, Telephone, Supplies and Materials: costs of workstation, file, print, and communications services (capital costs only), telephone usage, supplies, materials and miscellaneous items for operational personnel whose primary assignment involves network management or design. Proportional costs relative to the number of personnel are consistent with the baseline scenario.

2.f Training: costs for technical training for operational personnel whose primary assignment involves network management or design. Proportional costs relative to the number of personnel are consistent with the baseline scenario.

3. Other Costs: include network-related costs in addition to capital and personnel-related costs.

3.a Transmission: costs include bandwidth-based Frame Relay costs, packet-based X.25 costs, and duration-based dial-up traffic.
Short-term savings are predicted for frame relay traffic due to resizing of circuits for closer correlation to bandwidth requirements. These savings are based upon the findings of the recapacitation study (Task IV) that significant excess capacity is currently provided, primarily at the lowest (feeder level) of many USDA agency networks.

Savings due to Frame Relay recapacitation will not be predicted to persist due to dramatic increases in traffic (expected to grow by greater than 400% due largely to increasing Internet usage). After the initial years of recapacitation, the likelihood that inherent over-capacity will be reintroduced consistent with low levels of formal network management is strong. Absent enterprise-wide diagnostic capabilities, the capacity-based effects of order-of-magnitude usage increases will be perceived as apparent bandwidth requirements rather than presenting occasion for realignment. A linear reintroduction of over-capacity to baseline levels between years 2 and 5 of the life cycle period approximates the effects of bandwidth-based solutions for network misalignments over time.

Absorption of the dial-up and X.25 traffic into the Frame Relay traffic (except for smaller dial-up sites) will be expected based on effective network management strategies. Execution of the transition to Frame Relay will be inhibited by absence of formal network management, which is approximated by the conversion of X.25 and dial-up traffic to Frame Relay at a linear rate between years 2 and 5 of the life cycle.

3.b Maintenance: costs of hardware and software maintenance agreements are estimated using the same metrics as in the baseline scenario due to continued agency-level asset management.

3.c Contracted Services: costs for telecommunications-related engineering and consulting contracts are estimated using the same metrics as in the baseline scenario due to continued agency-level asset management

3.d Operational Costs of Network Outages: The underlying characteristics of network performance (topology, bandwidth, etc.) have been altered only marginally from those under the baseline scenario. While the management of network performance would be predicted to improve due to full staffing of agency network management positions (described in 2.b), any improvement would be limited to a *reactive* dimension (related to identifying, diagnosing, and correcting a problem) rather than a *proactive* dimension (related to problem prevention). On the basis of reduced duration of the network interruptions, the affected number of critical messages on which the operational impact was established would be estimated to be reduced by 50% from those projected under the baseline scenario. The other factors from which the operational impact of network interruptions are derived (number of outages—uptime, bottlenecks—traffic volume, proportion of messages deemed to be critical requiring immediate delivery via other communication channels, and the effort to accomplish delivery via other communication channel) are unchanged from those estimated in the baseline scenario.

2.3 Managed Enterprise Network Alternatives

The fully managed TEN alternatives (Alternatives One, Two, and Three) are designed for survivability due to consolidated backbone network infrastructure, requiring higher expenditures for the additional backbone nodes, chords, and associated equipment necessary for improved survivability. Under Alternatives One, Two, and Three, USDA's wide-area network (WAN) infrastructure would be acquired, managed, and operated by an outside contractor. Outsourcing the department's WAN operations is a business strategy expected to achieve significant savings over the current, baseline operations through the quantitative and qualitative benefits of having sufficient technical staff to centrally manage a network of greater than 1000 nodes.

The centrally managed Enterprise Network Operations Center (ENOC) would be operated through a contractual vehicle negotiated between USDA and an outside contractor. The contractor would have two major responsibilities in implementing the WAN, to include: (1) the acquisition and maintenance of WAN hardware and software devices, and (2) network operations through monitoring, diagnosing, isolating, repairing and re-testing elements of the USDA WAN.

2.3.1 Basis of Comparison

For Alternatives One, Two, and Three, the cost structure underlying USDA's network-related products and services would change significantly under the adoption of the TEN approach. The overall structure of the TEN design alternatives compared to the Recapacitation alternative are depicted in Figure 2, which provides the high-level allocation of costs between the categories. The following major changes to costs estimated for Alternative Zero may be anticipated as a result of implementing TEN:

- Capital: USDA expenditures for acquisition and installation of routers (and associated software) to maintain and expand network capabilities would be discontinued because hardware, software, and support services would be "bundled" as part of end-to-end services provided by contractor.
- Personnel-related: A TEN program management office would be required to manage the selection, funding, and direction of the contractor to manage and maintain the comprehensive network.
- Personnel-related: Contractor-provided network maintenance services would supplant network support staff who currently provide support to agencies in current disparate networks within USDA. Organic resources would still be required for the determination of network architecture, establishment of telecommunications policy, and engineering of TEN configuration based on planned growth and changes in utilization (due, for example, to new mission applications). Operational responsibilities performed by USDA personnel in conjunction with activities including the

maintenance of separate SNA networks and the local reporting of WAN-related problems by LAN maintenance staff would be expected to continue under the TEN environment, although the level of effort associated with these activities would be diminished because of the increasing reliance on TEN due to performance management capabilities of the enterprise network.

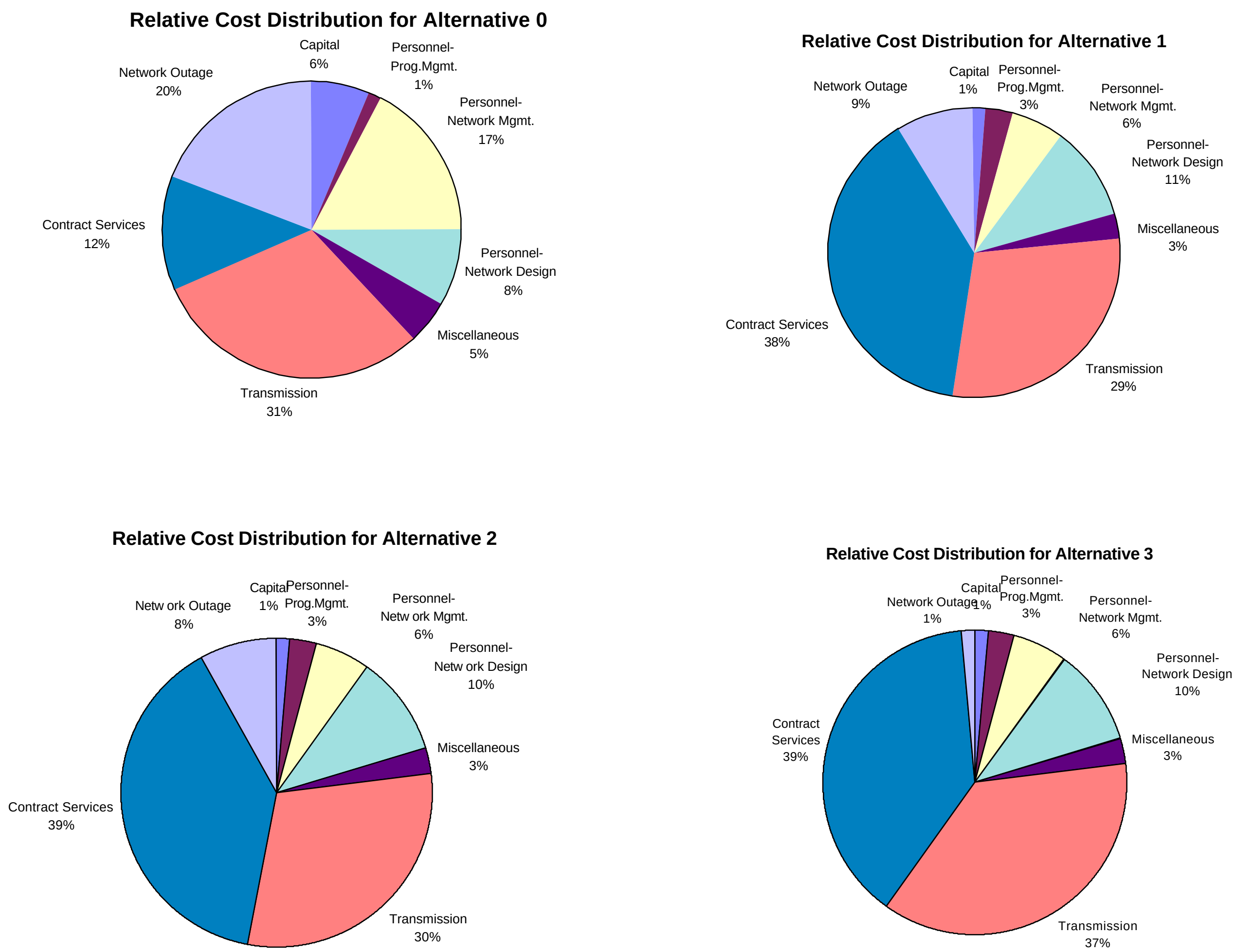

Figure 2 Comparison of High-Level Cost Composition of Alternatives

<u>Transmission</u>:

Reconfiguration of the disparate agency networks to form an enterprise network would necessitate significant changes to network traffic. Projections of traffic levels relative to the baseline have been developed as part of the study: <u>Development of Initial Enterprise Design Alternatives—Task VI</u>

Report. Additional cost efficiencies over the recapacitation alternative would be expected due to expedited transition of X.25 and dial-up traffic to Frame Relay, enabled by comprehensive planning and design capabilities.

- Operational Effects of Network Outages: Further improvements in the performance and reliability of telecommunications services are expected under the TEN alternatives. For Alternative One and Alternative Two, improvements in the degree of impact over the recapacitaion approach (Alternative Zero) would be anticipated due to the lessened vulnerability to network-wide failures. An order of magnitude improvement in network reliability is anticipated under Alternative Three. A fully redundant backbone infrastructure enhances the survivability of Alternative Three to the extent that the major and catastrophic categories of network outages and bottlenecks would be eliminated.

In addition to the preceding changes, the principal departure from the basis of estimate used to project the cost of Alternative Zero, Recapacitation, is the use of contracted services as the basis for TEN infrastructure provision/maintenance and network management support. Figure 3 depicts the transition from government equipment and personnel (under the Recapacitation approach) to contracted services under the TEN approach. Because of the significance of the acquired services for the TEN approach, particular attention has been focused on the estimation methodology for these services. Cost estimates for contractor-provided services have been developed by analyzing the separate cost elements of staffing, infrastructure, and other costs incurred by the contractor. Contractor-based costs are presented in the following categories, as though services were to be purchased separately:

- Staffing to Support Transition
- Staffing to Support Operations and Maintenance
- Infrastructure
- Third Party and Other Costs.

The rationale for representing contracted services as though separately purchased is based on the cost accounting technique of linking costs to productive factors. Identifying the cost components that ultimately account for varying levels of expenditure by the TEN contractor enables the resulting estimates to be tied more closely to verifiable rates and values. Validation of staffing levels, labor rates, and maintenance charges using comparably priced sources provides independent confirmation of the basis of estimate. The manner in which actual costs are incurred by USDA through the TEN contract would be determined by the Contract Line Item Number (CLIN) structure. Assuming competitive acquisition of TEN contracted services, however, allows the determination of total cost independent of contract structure, since the successful bidder would have to allocate costs among CLINs using a cost-competitive method. Establishment of an appropriate CLIN structure has the dual goals of balancing risks between USDA and the contractor in an acceptable manner, as well as enabling service provision (and billing) in conformance with USDA's business processes. A key input into the development of a

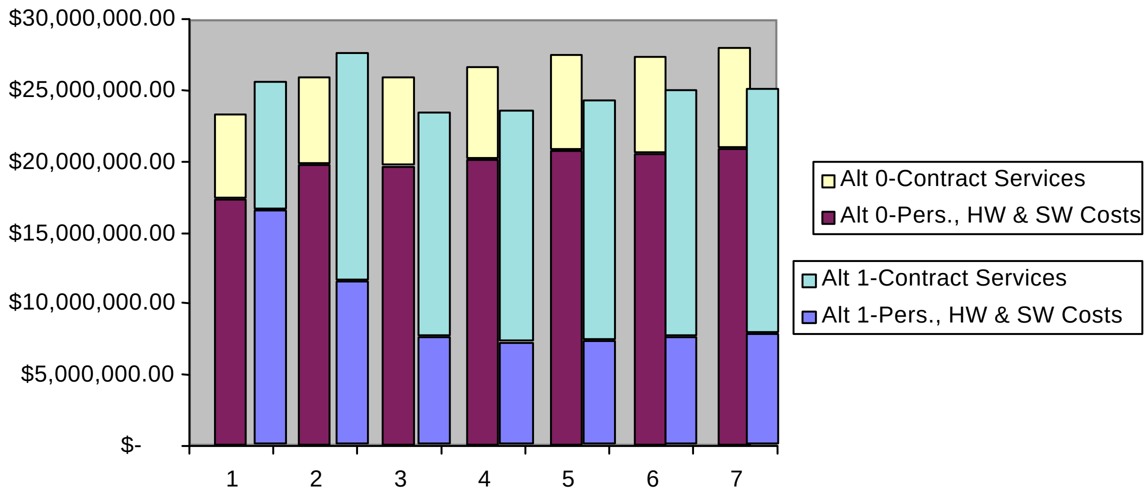

Figure 3 Transition to Contracted Services under TEN Alternatives

CLIN structure for the TEN contract will be the study of cost charge-back methods performed by Performance Engineering Corporation in conjunction with the financial analysis documented by this report.

2.3.2 Transition Staffing

An eighteen-month transitional period is anticipated for Alternatives One, Two, and Three. As seen in Table 8, the majority of the Contract Level Project Management team will participate in the transition for most of the 18-month period. To augment the regular staff in resolving connectivity issues and assessing bandwidth requirements, two additional performance engineers are projected for the transition's duration. The Help Desk staff is expected to incrementally join the transition efforts, while the majority of the Inventory Maintenance team is not expected to begin until this phase is complete.

Table 8 Estimated ENOC Transition Staff for Alternative One

	Job Category	FTE	Months	Tot Hrs	Rate	Total
MANAGEMENT	**Contract Level Project Management**					
	Program Manager	1	18	2,708	$ 157.28	$ 425,846
	Project Manager	1	18	2,708	$ 109.95	$ 297,680
	Administrative Assistant	1	18	2,708	$ 21.78	$ 58,970
	Technical Writer	1	16	2,407	$ 40.57	$ 97,648
	Technical Manager	2	18	5,415	$ 81.66	$ 442,175
	Senior Systems Analyst	1	18	2,708	$ 64.98	$ 175,934
	Performance Assessment					
	Performance Engineer	4	18	10,830	$ 59.21	$ 641,289
	Database Administrator	1	18	2,708	$ 70.44	$ 190,726
	Management Reporting					
	Senior Systems Analyst	0	0	0	$ 64.98	$ -
	Applications Programmer	1	18	2,708	$ 65.36	$ 176,953
	Database Administrator	1	18	2,708	$ 70.44	$ 190,726
OPERATIONS	**Help Desk Operations**					
	Technical Manager	2	14	4,212	$ 81.66	$ 343,914
	Senior Systems Analyst	5	8	6,017	$ 64.98	$ 390,964
	Help Desk Analyst	6	9	8,123	$ 42.81	$ 347,746
	Administrative Assistant	1	9	1,354	$ 21.78	$ 29,485
	ENOC Problem Evaluation					
	Telecommunications Specialist	7	9	9,476	$ 50.49	$ 478,489
	Problem Resolution & End User Support					
	Technical Manager	2	14	4,212	$ 81.66	$ 343,914
	Certified Network Engineer	6	13	11,733	$ 74.55	$ 874,714
	Network Specialist	6	13	11,733	$ 48.71	$ 571,442
	WAN Integrator/WAN Technician	6	13	11,733	$ 52.23	$ 612,766
	Senior Systems Analyst	4	9	5,415	$ 64.98	$ 351,867
	Systems Analyst	5	9	6,769	$ 56.15	$ 380,089
	Systems/Network Administrator	5	13	9,777	$ 60.42	$ 590,714
	Administrative Assistant	1	14	2,106	$ 21.78	$ 45,866
INVNTRY	**Asset Management Reporting**					
	Technical Manager	1	17	2,557	$ 81.66	$ 208,805
	Logistics Specialist	3	16	7,220	$ 51.75	$ 373,640
	Systems Analyst	3	9	4,061	$ 56.15	$ 228,053
	Maintenance					
	Logistics Specialist	1	8	1,203	$ 51.75	$ 62,273
	Systems Analyst	0	0	0	$ 56.15	$ -
	Telecommunications Specialist	4	10	6,017	$ 50.49	$ 303,803
	TOTAL					**$ 9,236,492**

Although staffing was depicted for Alternative One, Alternatives Two and Three have very similar projected staffing profiles, requiring only slight increments of additional installation effort to account for differences in infrastructure (described in Section 2.3.4, below). Other services associated with transition to these networks (e.g., project management, inventory control, etc.) are projected to be similar between the network options. Contractual costs have been estimated based on sampling of comparable labor rates, staffing levels, and other direct costs in government and commercial environments. Labor categories are described in the following table.

Table 9 ENOC Staffing Job Descriptions

Job Category	Descriptions
Contract Level Project Management	
Program Manager	Responsibilities include negotiate, start-up, staff-up and manage day-to-day contractual requirements
Project Manager	Duties include staff-up, start-up, manage, day-to-day field operations and h/w and s/w acquisition
Administrative Assistant	Performs management administrative functions
Technical Writer	Supports the development of contract deliverables, transition plan, implementation plan, maintenance plan, asset management plan, Service level agreement
Technical Manager	Manages testing, installing, set-up, configuration operations, quality control (QC), reporting and analytical requirements, and functions as deputy program manager
Senior Systems Analyst	Responsible for QC and financial reporting analyses
Performance Assessment	
Performance Engineer	Monitors, analyzes, tracks, and reports on the router and WAN Interface performance metrics, identifies circuits needed
Database Administrator	develops network management tools
Management Reporting	
Senior Systems Analyst	Responsible for management and financial reports
Applications Programmer	Develops and manages the reporting tools
Database Administrator	Supports the development of the reporting tools

Job Category	Descriptions
Help Desk Operations	
Technical Manager	Responsible for help desk start-up, staffing, and day-to-day operations
Senior Systems Analyst	Runs a help desk shift and performs callbacks and statistical trend analysis
Help Desk Analyst	Responsible for problem receipt and tracking
Administrative Assistant	Supports operations staff administrative functions
ENOC Problem Resolution	
Telecommunications Specialist	Responsible for initial ENOC on duty 8/5 support, on-call support, WAN H/W and S/W problem resolution
Problem Resolution & User Support	
Technical Manager	Manages field operations start-up, implementation, ordering, problem resolution and user support efforts
Certified Network Engineer	Performs network analysis, engineering functions and interfaces with the USDA Network Engineers
Network Specialist	Installs, tests, maintains, and troubleshoots data networks
WAN Integrator/WAN Technician	Evaluates, selects, installs, tests and maintains WANs and interfaces with USDA Network Engineers
Senior Systems Analyst	Provides e-mail administration and support
Systems Analyst	Supports Sr. systems analysts in administering e-mail capabilities and trouble ticketing
Systems/Network Administrator	Responsible for network administration and support
Administrative Assistant	Supports field operations administrative functions

Asset Management Reporting	
Technical Manager	Responsible for creating baseline management, ordering, and tracking orders, and managing inventory personnel
Logistics Specialist	Performs QA/QC Inspections of incoming hardware, and spot checks the inventory
Systems Analyst	Prepares the inventory reports
Documentation Analyst	Assists systems analyst preparing inventory reports
Maintenance	
Logistics Specialist	Analyzes inventory data and inventory databases
Systems Analyst	Maintains WAN inventory for day-to-day operations
Telecommunications Specialist	Supports help desk in isolating hardware functions

The total transition timeframe is projected for 18 months. The following steps in the transition to the contractor-maintained network are scheduled:

- Contract award is expected by November 1998 (Year 1, month 2 of the analysis period).
- Equipment ordering, installation, and staffing of the ENOC are expected to continue through April 1999 (Year 1, month 7 of the analysis period).
- In conjunction with the award of the FTS2000 follow-on contract, circuits should be ordered in April 1999.
- Based on 60 day lead-time for circuit orders, FTS2001 service should be available starting July 1999 (Year 1, month 10 of the analysis period).
- After a one-month period to test the backbone network, transition of the current networks on an agency by agency basis begins in August 1999 (Year 1, month 11 of the analysis period).
- Based on a nine-month timeframe, all agency networks are transitioned to the TEN network by April 2000 (Year 2, month 7 of the analysis period).
- The remainder of Year 2, and Years 3 through 7 are considered the operational portion of the analysis period.

Alternatives One, Two, and Three incorporate the information technology (IT) strategy of network outsourcing. This strategy focuses on the need for highly skilled expertise to centrally implement and monitor a wide-area network (WAN). In the current environment of today’s dynamic telecom industry, organizations are realizing that they have neither the budget nor the time to develop their internal staff’s skill as quickly as the technology is evolving. Tapping into a rich pool of technically competent outsourced personnel will provide the expertise to install, design, troubleshoot, and manage a WAN’s infrastructure and services, in addition to providing the resources necessary for USDA to begin a phased migration from its X.25 networks and remaining dial-up networks.

2.3.3 Operations and Maintenance Staffing

Table 10 depicts projected staff required to staff the ENOC, and estimates the annual cost. As in the transition staffing, Alternative One, Alternatives Two and Three have very similar projected staffing profiles.

Table 10 Estimated ENOC Operations and Maintenance Staff

	Job Category	FTE	% Time	Tot Hrs	Rate	Total
MANAGEMENT	**Contract Level Project Management**					
	Program Manager	1	1	1,805	$157.28	$ 283,897
	Project Manager	1	1	1,805	$109.95	$ 198,453
	Administrative Assistant	1	1	1,805	$ 21.78	$ 39,313
	Technical Writer	1	1	1,805	$ 40.57	$ 73,236
	Technical Manager	2	1	3,610	$ 81.66	$ 294,783
	Senior Systems Analyst	1	1	1,805	$ 64.98	$ 117,289
	Performance Assessment					
	Performance Engineer	2	1	3,610	$ 59.21	$ 213,763
	Database Administrator	1	0.5	903	$ 70.44	$ 63,575
	Management Reporting					
	Senior Systems Analyst	1	1	1,805	$ 64.98	$ 117,289
	Applications Programmer	1	1	1,805	$ 65.36	$ 117,969
	Database Administrator	1	0.5	903	$ 70.44	$ 63,575
			0.5			
OPERATIONS	**Help Desk Operations**					
	Technical Manager	2	1	3,610	$ 81.66	$ 294,783
	Senior Systems Analyst	5	1	9,025	$ 64.98	$ 586,446
	Help Desk Analyst	6	1	10,830	$ 42.81	$ 463,661
	Administrative Assistant	1	1	1,805	$ 21.78	$ 39,313
	ENOC Problem Evaluation					
	Telecommunications Specialist	7	1	12,635	$ 50.49	$ 637,986
	Problem Resolution & End User Support					
	Technical Manager	2	1	3,610	$ 81.66	$ 294,783
	Certified Network Engineer	6	1	10,830	$ 74.55	$ 807,428
	Network Specialist	6	1	10,830	$ 48.71	$ 527,485
	WAN Integrator/WAN Technician	6	1	10,830	$ 52.23	$ 565,630
	Senior Systems Analyst	4	1	7,220	$ 64.98	$ 469,157
	Systems Analyst	5	1	9,025	$ 56.15	$ 506,785
	Systems/Network Administrator	5	1	9,025	$ 60.42	$ 545,275
	Administrative Assistant	1	1	1,805	$ 21.78	$ 39,313
			1			
INVENTORY	**Asset Management Reporting**					
	Technical Manager	1	1	1,805	$ 81.66	$ 147,392
	Logistics Specialist	3	0.3	1,625	$ 51.75	$ 84,069
	Systems Analyst	3	0.3	1,625	$ 56.15	$ 91,221
	Maintenance					
	Logistics Specialist	4	0.7	5,054	$ 51.75	$ 261,548
	Systems Analyst	4	0.7	5,054	$ 56.15	$ 283,799
	Telecommunications Specialist	4	1	7,220	$ 50.49	$ 364,563
	TOTAL					**$ 8,593,783**

Contractual costs have been estimated based on sampling of comparable labor rates, staffing levels, and other direct costs in government and commercial environments. Levels of contractor staffing are predicated on staffing levels of comparable nation-wide government networks.

2.3.4 Infrastructure

Assuming that the TEN network must be in place prior to cutover, the infrastructure that the contractor is required to provide is primarily at the concentrator and backbone levels. Routers associated with feeder nodes may be expected to be supplied as Government-Furnished-Equipment (GFE) and subsequently maintained (and replaced if necessary) by the contractor. The assumption for maintenance of the router inventory has been based on a repair and replace strategy, rather than a cyclical replacement strategy. Spares to provide for replacement of concentrator and backbones node routers are assumed to be provided as GFE following decommissioning of current Cisco 4000 and 7000 series routers after cutover. Spares to provide for replacement of feeder node routers are assumed to be covered by third-party maintenance agreements described in the following section. The third-party vendor is assumed to be responsible for replacement of routers that are too obsolete to repair.

Hardware necessary for Alternatives One, Two, and Three varies depending on the WAN complexity and its robustness. Alternative One is considered to be the low-cost, least robust solution comprised of eight backbone nodes and two chords. This alternative requires less high performance routers (i.e., Cisco 7000s) than Alternatives Two and Three. However, the savings realized within the backbone node are offset by additional routers required for the concentrator nodes (i.e., Cisco 4000s) since a higher number of them are needed in this implementation scenario. Alternative Two increases the backbone complexity by doubling the router backbone nodes while reducing the number of concentrator nodes. Alternative Three implements a fully redundant backbone, ensuring a higher performing network with a comparable acquisition cost in relation to Alternatives One and Two. Table 11 depicts the additional hardware required to implement each alternative.

Table 11 Estimated Infrastructure Requirements of alternatives

	NODES								
	Backbone			Concentrator			Feeder		
	7000	4000	2500	7000	4000	2500	7000	4000	2500
Alternative 1	8	0	0	13	112	0	0	0	12
Alternative 2	16	0	0	8	109	0	0	0	12
Alternative 3	18	0	0	6	110	0	0	0	12

2.3.5 Third-Party and Other Costs

Other costs that may be anticipated for the contractor include additional costs related to router maintenance, including travel to locations maintained directly by the contractor (concentrator and backbone node locations) and third-party maintenance agreements for nationwide coverage of feeder node routers. The remaining costs of operation are comparable to those costs already described for the baseline and the recapacitation alternative, allowing for reductions where activities or infrastructure are no longer required due to the TEN contractor.

2.3.6 Impact on Transmission Costs

A significant impact of enhanced capabilities for network management is the ability to expedite the absorption of the dial-up and X.25 traffic onto the Frame Relay circuits. This accelerated cutover of more costly traffic onto cost effective means of transmission will produce favorable transmission costs relative to the baseline scenario and Alternative Zero, which requires a longer timeframe to assume dial-up and X.25 traffic. The TEN alternatives will be expected to accomplish the absorption of X.25 and dial-up traffic (except for smaller dial-up sites) by Year 3. Figure 4 depicts the accelerated movement of X.25 and dial-up traffic onto frame relay circuits, comparing Alternative One and Alternative Zero (which accomplishes the cutover over a longer timeframe).

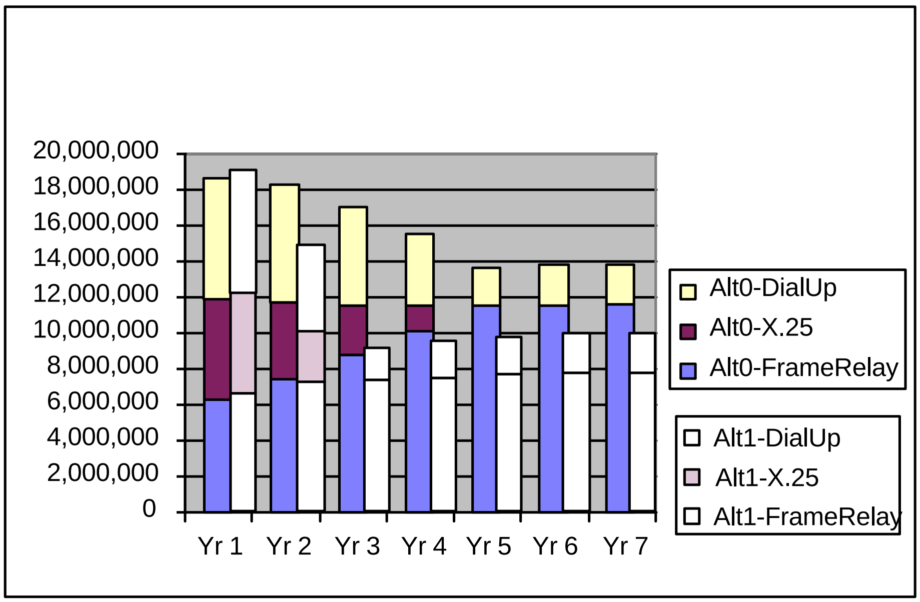

Figure 4 Projected Conversion of X.25 and Dial-up to Frame Relay

2.3.7 Life Cycle Cost Projections

Costs for Alternatives One, Two, and Three are depicted in Tables 12, 13, and 14 respectively. Descriptions of the basis of estimate are contained in the subsequent paragraphs. Costs have been classified into the same general categories as the baseline and Alternative Zero, although costs estimates for Contracted Services have been further divided to provide visibility to the different types of services provided under the proposed TEN contract.

Table 12 Projected Life Cycle Costs for Alternative One

Alternative 1 - Min. Redundanc	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Total
A. ONE-TIME IMPLEMENTATION COSTS								
1. Capital Costs								
a. H/W Acquisition	2,275,960	322,400	322,400	274,400	274,400	274,400	274,400	4,018,360
b. S/W Acquisition	0	60,000	0	0	0	0	0	60,000
c. Installation, Config. & Testing	101,529	0	0	0	0	0	0	101,529
Subtotal - Capital	2,377,489	382,400	322,400	274,400	274,400	274,400	274,400	4,179,889
2. Personnel Costs								
a. Program Mgmt.	1,521,634	1,082,269	1,114,737	1,148,180	1,182,625	1,218,104	1,254,647	8,522,196
b. Network Mgmt., Maint., & Security	7,198,168	5,436,029	1,314,518	872,253	898,421	925,373	953,134	17,597,895
c. Network Policy/Architecture/Design	3,991,863	4,111,619	4,234,967	4,362,016	4,492,877	4,627,663	4,766,493	30,587,498
d. Office, Furniture, & non-OA Equip.	791,040	651,218	511,396	486,220	500,806	515,831	531,306	3,987,817
e. OA, Telephone, Supplies, and Materials	203,034	167,146	131,258	124,796	128,540	132,397	136,368	1,023,540
f. Training	197,760	162,805	127,849	121,555	125,202	128,958	132,826	996,954
Subtotal - Personnel	13,903,498	11,611,085	7,434,726	7,115,020	7,328,471	7,548,325	7,774,775	62,715,900
3. Other Costs								
a. Transmission	19,127,555	15,110,089	9,205,373	9,509,129	9,716,922	9,843,203	9,902,063	82,414,335
b. H/W and S/W Maintenance	1,137,980	161,200	161,200	137,200	137,200	137,200	137,200	2,009,180
c. Contracted Services								
c.1 Existing Contracts	7,441,050	4,731,884	4,873,841	5,020,056	5,170,658	5,325,778	5,485,551	38,048,817
c.2 Transition Staffing	3,331,796	5,904,696						9,236,492
c.3 Operations & Maintenance Staffing		3,580,743	8,851,596	9,117,144	9,390,659	9,672,378	9,962,550	50,575,071
c.4 Infrastructure	331,500	663,000	738,000	813,000	888,000	963,000	375,000	4,771,500
c.5 3rd Party, & Other Costs		1,684,614	1,841,390	1,896,632	1,953,531	2,012,137	2,072,501	11,460,804
d. Network Outage Operational Impacts	1,941,173	1,097,658	1,424,453	2,268,692	3,275,192	4,502,429	5,967,802	20,477,399
Subtotal - Other Costs	33,311,053	32,933,885	27,095,854	28,761,853	30,532,162	32,456,125	33,902,667	218,993,599
Total	49,592,041	44,927,370	34,852,980	36,151,273	38,135,033	40,278,850	41,951,842	285,889,389

The costs estimated for Alternative One are presented in the following categories. Only categories for which costs are different from Alternative Zero have been described in detail:

1. Capital Costs: costs represent additional infrastructure acquisition or upgrade, including hardware and software.

1.a Hardware: Hardware costs for year one of the analysis are based on the cyclical replacement of the router inventory using a five year replacement cycle, equivalent to the purchase of 20% of the current inventory value annually. For the remainder of the analysis period, router acquisition/replacement will be part of contracted services provided under the TEN acquisition. These costs are included within category 3.d, Contracted Services. Cyclical replacement of other infrastructure, such as multiplexers, and front-end processors, are still addressed in this category because these would not be outsourced. Cyclical replacement of front-end processors is assumed to be discontinued after Year 4, due to decreased reliance on SNA networks under a graduated disinvestment strategy, which would maintain the capability, but not upgrade resources for proprietary technologies.

Replacement of items external to the Frame Relay network operated by the TEN vendor (e.g., voice/data multiplexers) are included within this category, and are based on a five year replacement cycle, equivalent to the purchase of 20% of the current inventory value annually.

1.b Software: Software costs are based on periodic technical refreshment of the monitoring capability for network activity, and will be part of contracted services provided under the TEN acquisition. Software purchases associated with government-maintained hardware (as described in 1.a, above) would follow a comparable disinvestment strategy, avoiding technology refreshment in the outyears of the analysis period.

1.c Installation and Testing: The cost of installation and testing of hardware and software. Installation and testing will be provided under the TEN contract, except for government-maintained hardware (as described in 1.a, above).

2. Personnel Costs: salary and overhead costs for personnel involved in the operation and maintenance of current USDA networks and any costs associated with those personnel (such as office space, supplies and materials, and furniture).

2.a. Program Management: costs of managing the staff effort, budgets, and contracts under the consolidated TEN program. Program management estimates are based on the *Telecommunications Network Stabilization and Migration Program (TNSMP) Plan, Version 1.0, October 1, 1997*. These positions are assumed to originate within the Telecommunications Services and Operations Office. Positions reflected in the Program Management category are excluded from the Network Architecture/ Design category to avoid double counting.

2.b. Network Management, Security, and Maintenance: costs related to TEN operation. Personnel responsible for central maintenance are expected to be contractor staff, and are included within category 3.c, Contracted Services. Government personnel involved in the TEN program are reflected in staffing for categories 2.a and 2.c, Program Management and Network Architecture/Design.

Improved network management of routers due to central management would result in an offsetting reduction of effort estimated for support staff whose primary role is Local Area Network (LAN) maintenance (as described for Alternative Zero). An additional level of improvement over the baseline scenario is projected because of contractor responsibility for troubleshooting and resolution of WAN-related performance problems, including repair and replacement of router software/hardware. The only remaining responsibility for LAN maintenance personnel is initial problem reporting (primarily for those cases not detected by network management software). The proportional effort allocated to these activities is estimated at approximately 8 hours per incident (projected based on hardware outages—as a proxy for failures not detected centrally— which are estimated based on Mean Time To Failure of 70,000 hours). Salaries for personnel are based on average costs for applicable USDA series 0334, Computer Specialist, and 0391, Telecommunications Specialist.

2.c. Network Architecture/Design: costs related to policy and oversight of networks. Includes positions within the Associate Chief Information Officer - Telecommunications Services and Operations (excluding personnel responsible for telephone), as well as positions within the Office of the CIO that are in the 0391 series, Telecommunications Specialist.

Positions that have been transferred to the TEN program office would be anticipated to be replaced, resulting in expanded network engineering to plan and design the provision of additional increments of telecommunications products and services based on proactive understanding of departmental requirements.

2.d. Office, Furniture & Equipment: office space costs for operational personnel whose primary assignment involves network management or design. Proportional cost relative to the number of personnel is consistent with the baseline scenario.

2.e Office Automation, Telephone, Supplies and Materials: costs of workstation, file, print, and communications services (capital costs only), telephone usage, supplies, materials and miscellaneous items for operational personnel whose primary assignment involves network management or design. Proportional cost relative to the number of personnel is consistent with the baseline scenario.

2.f. Training: costs for technical training for operational personnel whose primary assignment involves network management or design. Proportional cost relative to the number of personnel is consistent with the baseline scenario.

3. Other Costs: include network-related costs in addition to capital and personnel-related costs.

3.a. Transmission: costs include bandwidth-based Frame Relay costs, packet-based X.25 costs, and duration-based dial-up traffic. Interim savings are predicted for year one frame relay traffic due to resizing of circuits for closer correlation to bandwidth requirements. These savings are based upon the findings of the recapacitation study (Task IV) that order of magnitude increments of superfluous capacity are currently available, primarily at the lowest (feeder level) of many USDA agency networks.

After year one, Frame Relay network changes are estimated to decrease 47% based on the Development of Initial Enterprise Design Alternatives—Task VI Report.

Expedited absorption of the dial-up and X.25 traffic into the Frame Relay traffic (except for smaller dial-up sites) will be predicted based on effective network management strategies, resulting in the conversion of X.25 and dial-up traffic to Frame Relay at a linear rate in years 2 and 3 of the life cycle period.

3.b. Maintenance: costs of hardware and software maintenance agreements for routers are excluded because these costs are included within the contracted services category. Maintenance of other components (e.g., multiplexers, routers) are estimated based on 10% of installed base, which is consistent with prevalent arrangements for maintenance agreements.

3.c. Contracted Services: costs for telecommunications-related engineering and consulting contracts. Contract cost categories are based upon factors that drive contractor cost, such as personnel, equipment, and third-party services, rather than on contractual categories (e.g., Contract Line Item Number—CLIN).

3.c.1 Contracted Services—Existing: costs for existing contracts that are projected to still be required in the TEN environment (e.g., Headquarters LAN Maintenance). These estimates reflect the replacement of consulting services by the available contractor network engineering positions included within ENOC staffing. The basis of estimate is the reduction of contract services for existing contracts to FY96 levels.

3.c.2 Contracted Services—Transition: costs for contractor personnel necessary for start-up of the TEN service. These costs are projected to be incurred prior to cutover in second quarter of FY2000, and have been described in section 2.3.2.

3.c.3 Contracted Services—Operations and Maintenance: cost for contractor management of TEN, which have been described in Section 2.3.3.

3.c.4 Infrastructure—Costs for contractor financing of equipment purchased for TEN (in addition to Government Furnished Equipment). This equipment is principally required for backbone and concentrator nodes described in Section 2.3.4. Routers for feeder nodes are assumed to be government furnished. Levels of expense are based on a capital budgeting approach, utilizing the yearly depreciation expense (assuming 5 year life cycle) as the basis of cost, and allocating a proportional overhead of 25% to account for debt service, administration, and fee.

3.c.5 Third Party and Other Costs—Other costs related to maintenance of TEN operations. Maintenance is assumed to be provided by third party for nationwide locations (viz., routers for feeder nodes). Contractor-provided maintenance using depots and remote staff should approximate third party cost. Maintenance of concentrator and backbone routers has been included within the projected TEN staffing, although travel has been estimated for contractor staff to destinations of concentrator and backbone nodes that do not have permanent staff.

3.d. Operational Costs of Network Outages: Under this alternative, duration and degree of impact would be limited by improved survivability. Estimates for enterprise-wide (catastrophic) outages have been revised to reflect less vulnerability based on the network modeling, which predicts approximately 19% of the total network is the maximum impact (as opposed to losing the entire network as is possible in the current environment). Assumptions concerning reduced duration of network interruptions due to better diagnostic and response capabilities have been continued from the recapacitation alternative (expected to limit the affected number of critical messages to 50% of those projected under the baseline scenario).

Table 13 Projected Life Cycle Costs for Alternative Two

Alternative 2 - Med. Redundan	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Total
A. ONE-TIME IMPLEMENTATION COSTS								
1. Capital Costs								
a. H/W Acquisition	2,275,960	322,400	322,400	274,400	274,400	274,400	274,400	4,018,360
b. S/W Acquisition	0	60,000	0	0	0	0	0	60,000
c. Installation, Config. & Testing	101,529	0	0	0	0	0	0	101,529
Subtotal - Capital	2,377,489	382,400	322,400	274,400	274,400	274,400	274,400	4,179,889
2. Personnel Costs								
a. Program Mgmt.	1,521,634	1,082,269	1,114,737	1,148,180	1,182,625	1,218,104	1,254,647	8,522,196
b. Network Mgmt., Maint., & Security	7,198,168	5,436,029	1,314,518	872,253	898,421	925,373	953,134	17,597,895
c. Network Policy/Architecture/Design	3,991,863	4,111,619	4,234,967	4,362,016	4,492,877	4,627,663	4,766,493	30,587,498
d. Office, Furniture, & non-OA Equip.	791,040	651,218	511,396	486,220	500,806	515,831	531,306	3,987,817
e. OA, Telephone, Supplies, and Materials	203,034	167,146	131,258	124,796	128,540	132,397	136,368	1,023,540
f. Training	197,760	162,805	127,849	121,555	125,202	128,958	132,826	996,954
Subtotal - Personnel	13,903,498	11,611,085	7,434,726	7,115,020	7,328,471	7,548,325	7,774,775	62,715,900
3. Other Costs								
a. Transmission	19,298,105	16,128,973	10,224,257	10,528,013	10,735,806	10,862,087	10,920,947	88,698,190
b. H/W and S/W Maintenance	1,137,980	161,200	161,200	137,200	137,200	137,200	137,200	2,009,180
c. Contracted Services								
c.1 Existing Contracts	7,441,050	4,731,884	4,873,841	5,020,056	5,170,658	5,325,778	5,485,551	38,048,817
c.2 Transition Staffing	3,512,708	5,904,696						9,417,404
c.3 Operations & Maintenance Staffing		3,586,743	8,866,428	9,132,421	9,406,394	9,688,586	9,979,243	50,659,816
c.4 Infrastructure	349,500	699,000	774,000	849,000	924,000	999,000	375,000	4,969,500
c.5 3rd Party, & Other Costs		1,741,965	1,898,741	1,955,703	2,014,374	2,074,806	2,137,050	11,822,639
d. Network Outage Operational Impacts	1,928,679	1,079,094	1,393,463	2,219,335	3,203,939	4,404,476	5,837,970	20,066,956
Subtotal - Other Costs	33,668,022	34,033,556	28,191,931	29,841,729	31,592,371	33,491,933	34,872,961	225,692,503
Total	49,949,009	46,027,041	35,949,057	37,231,149	39,195,242	41,314,657	42,922,136	292,588,292

The costs estimated for Alternative Two are presented in the following categories. Only categories for which costs are different from Alternative One have been described in detail:

1. Capital Costs: no change from Alternative One.

2. Personnel Costs: no change from Alternative One.

3. Other Costs: include network-related costs in addition to capital and personnel-related costs.

3.a. Transmission: factor relative to the current Frame Relay expenditure of 35% decrease is based on the study: Development of Initial Enterprise Design Alternatives—Task VI Report. X.25 and dial-up levels are projected on the same basis as Alternative One.

3.b. Maintenance: no change from Alternative One.

3.c. Contracted Services: costs for telecommunications-related engineering and consulting contracts. Contract cost categories are based upon factors that drive contractor cost, such as personnel, equipment, and third-party services, rather than on contractual categories (e.g., Contract Line Item Number—CLIN).

3.c.1 Contracted Services—Existing: no change from Alternative One.

3.c.2 Contracted Services—Transition: Additional installation for more extensive backbone under this alternative has been estimated based on the proportion of additional infrastructure, as described in Section 2.3.4.

3.c.3 Contracted Services—Operations and Maintenance: Additional maintenance effort has been calculated based on a proportional allocation of additional infrastructure required for more extensive backbone under this alternative. A factor of 10% of the value of additional assets (as described in Section 2.3.4) has been used to estimate this cost.

3.c.4 Infrastructure—based on routers for concentrator and backbone nodes, which have been described in Section 2.3.4.

3.c.5 Third-Party and Other Costs— Travel associated with maintenance of additional infrastructure (required by more extensive backbone infrastructure than other alternatives) has been estimated based on a proportion of the additional staffing required (estimated in 3.c.4).

3.d. Operational Costs of Network Outages: As in Alternative One, duration and degree of impact would be limited by improved survivability. Estimates for enterprise-wide (catastrophic) outages have been revised to reflect less vulnerability based on the network modeling, which predicts approximately 17% of the total network is the maximum impact (as opposed to losing the entire network as is possible in the current environment). Assumptions concerning reduced duration of network interruptions due to better diagnostic and response capabilities have been continued from the recapacitation alternative (expected to limit the affected number of critical messages to 50% of those projected under the baseline scenario.)

Table 14 Projected Life Cycle Costs for Alternative Three

Alternative 3 - Full Redundanc	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Total
A. ONE-TIME IMPLEMENTATION COSTS								
1. Capital Costs								
a. H/W Acquisition	2,275,960	322,400	322,400	274,400	274,400	274,400	274,400	4,018,360
b. S/W Acquisition	0	60,000	0	0	0	0	0	60,000
c. Installation, Config. & Testing	101,529	0	0	0	0	0	0	101,529
Subtotal - Capital	2,377,489	382,400	322,400	274,400	274,400	274,400	274,400	4,179,889
2. Personnel Costs								
a. Program Mgmt.	1,521,634	1,082,269	1,114,737	1,148,180	1,182,625	1,218,104	1,254,647	8,522,196
b. Network Mgmt., Maint., & Security	7,198,168	5,436,029	1,314,518	872,253	898,421	925,373	953,134	17,597,895
c. Network Policy/Architecture/Design	3,991,863	4,111,619	4,234,967	4,362,016	4,492,877	4,627,663	4,766,493	30,587,498
d. Office, Furniture, & non-OA Equip.	791,040	651,218	511,396	486,220	500,806	515,831	531,306	3,987,817
e. OA, Telephone, Supplies, and Materials	203,034	167,146	131,258	124,796	128,540	132,397	136,368	1,023,540
f. Training	197,760	162,805	127,849	121,555	125,202	128,958	132,826	996,954
Subtotal - Personnel	13,903,498	11,611,085	7,434,726	7,115,020	7,328,471	7,548,325	7,774,775	62,715,900
3. Other Costs								
a. Transmission	19,949,842	19,526,077	13,621,361	13,925,117	14,132,910	14,259,191	14,318,051	109,732,550
b. H/W and S/W Maintenance	1,137,980	161,200	161,200	137,200	137,200	137,200	137,200	2,009,180
c. Contracted Services								
c.1 Existing Contracts	7,441,050	4,731,884	4,873,841	5,020,056	5,170,658	5,325,778	5,485,551	38,048,817
c.2 Transition Staffing	3,527,784	5,904,696						9,432,480
c.3 Operations & Maintenance Staffing		3,587,243	8,867,664	9,133,694	9,407,705	9,689,936	9,980,635	50,666,878
c.4 Infrastructure	351,000	702,000	777,000	852,000	927,000	1,002,000	375,000	4,986,000
c.5 3rd Party, & Other Costs		1,746,747	1,903,524	1,960,629	2,019,448	2,080,032	2,142,433	11,852,813
d. Network Outage Operational Impacts	1,379,676	291,916	81,782	126,459	182,562	250,969	332,650	2,646,014
Subtotal - Other Costs	33,787,332	36,651,764	30,286,372	31,155,156	31,977,483	32,745,106	32,771,519	229,374,733
Total	50,068,319	48,645,250	38,043,499	38,544,576	39,580,354	40,567,831	40,820,694	296,270,522

The costs estimated for Alternative Three are presented in the following categories. Only categories for which costs are different from Alternatives One and Two have been described in detail:

1. Capital Costs: no change from Alternatives One and Two.

2. Personnel Costs: no change from Alternatives One and Two.

3. Other Costs: include network-related costs in addition to capital and personnel-related costs.

3.a. Transmission: factor relative to the current Frame Relay expenditure of 6.7% increase is based on the study: Development of Initial Enterprise Design Alternatives—Task VI Report. X.25 and dial-up levels are projected on the same basis as Alternatives One and Two.

3.b. Maintenance: no change from Alternatives One and Two.

3.c. Contracted Services: costs for telecommunications-related engineering and consulting contracts. Contract cost categories are based upon factors that drive contractor cost, such as personnel, equipment, and third-party services, rather than on contractual categories (e.g., Contract Line Item Number—CLIN).

3.c.1 Contracted Services—Existing: no change from Alternatives One and Two.

3.c.2 Contracted Services—Transition: Additional installation for more extensive backbone under this alternative has been estimated based on the proportion of additional infrastructure, as described in Section 2.3.4.

3.c.3 Contracted Services—Operations and Maintenance: Additional maintenance effort has been calculated based on a proportional allocation of additional infrastructure required for more extensive backbone under this alternative. A factor of 10% of the value of additional assets (as described in Section 2.3.4) has been used to estimate this cost.

3.c.4 Infrastructure—based on routers for concentrator and backbone nodes, which have been described in Section 2.3.4.

3.c.5 Third-Party and Other Costs— Travel associated with maintenance of additional infrastructure (required by more extensive backbone infrastructure than other alternatives) has been estimated based on a proportion of the additional staffing required (estimated in 3.c.4).

3.d. Operational Costs of Network Outages: An order of magnitude improvement in network reliability is anticipated under Alternative Three. A fully redundant backbone infrastructure enhances the survivability of Alternative Three to the extent that the major and catastrophic categories of network outages and bottlenecks would be eliminated. Only minor outages (based on the network performance analysis described as part of the baseline description) have been projected to occur under this alternative, with frequency expected to fall by 50%.
Other Benefits

3.0 Other Benefits

Many of the benefits of implementing the TEN project have already been identified as part of the life cycle costs developed in the preceding section. Quantifiable improvements in the provision of cost-effective telecommunications services, such as reduced requirements for network management personnel, increased network reliability avoiding negative operational effects (e.g., outages), and more efficient use of circuits, are classified as cost avoidance. These improvements reduce the level of expenditure to provide current types of services, or correct operational shortcomings to increase service levels, both of which have measurable consequences that are reflected in the life cycle cost. In comparing the alternatives, benefits can potentially be realized that can not be totally quantified. Benefits specific to telecommunications network operations have been identified in the following areas: Central Management, Configuration Management, Central Maintenance, Policy and Procedures, and Network Availability. Each is identified in Table 15 based on whether it exists in each design and is defined in the remaining paragraphs.

Table 15 Benefits Related to Telecommunications Network Operations

Category	Alternative 0	Alternative 1	Alternative 2	Alternative 3
Central Management		X	X	X
Configuration Management	X	X	X	X
Central Maintenance		X	X	X
Policy and Procedures		X	X	X
Network Availability	Poor	Satisfactory	Satisfactory	Outstanding

1. Central Management - Enables one organization to monitor, control, assess, support, implement and maintain a global network, minimizing, even potentially eliminating possible inconsistencies and incompatibilities, that are currently being seen in the Baseline and would still be seen in Alternative Zero.
2. Configuration Management - Critical element of a central management organization that focuses on ensuring compatibility of hardware and software within the WAN, maintains a database that tracks hardware and software trouble reports which are further used to perform trend analyses, maintains software licenses and firmware versions, and maintains a centralized database of routable addresses of the entire network. Under the current disparate network structure, which is perpetuated under Alternative 0, configuration management is dispersed among various agencies which may cause inconsistencies of the items identified earlier and may increase the potential for major network outages.
3. Central Maintenance - Enables one organization to manage, identify, isolate, replace, repair, re-test, and restore, WAN operations versus individualized maintenance teams dispersed throughout agencies that can disrupt services to other organizations. In addition, the Central maintenance team would also inform those organizations affected about actions to be taken to resolve a problem and how long it may take to restore operations.
4. Policy and Procedures - Specific concept of operations could be defined and enforced with a central maintenance organization. Also, a Service Level Agreement (SLA) can be established which defines goals necessary for successful contractor and WAN performance. These performance criteria assessments will be measured to determine whether the Contractor should be receive full or partial compensation.
5. Network Availability - The central managed network enables the USDA to establish guidelines, which are defined in the SLA, that result in better response to problem reporting. Also, the central managed network, which occurs on a 7/24 basis, will react (identify) a problem quicker, since they are monitoring the WAN through the use of automated tools which will alert the central managed operators of a problem.

In addition to the benefits of enhanced network operations, implementing an enterprise network provides the possibility for future department-wide technology applications, which generate benefits of interoperability between related functions that may reside in different organizational units. These applications include Inventory Control, Electronic Procurement, and other financial and resource management capabilities. While enterprise-wide capabilities, such as the preceding examples of administrative systems require additional investments that are not contemplated as part of the TEN project per se, the enterprise network is required as a prerequisite foundation to creating the potential for follow-on applications.

Aside from particular applications, which may be developed in response to specific mission requirements, general requirements for enhanced workgroup collaboration (by personnel in separate organizations who perform related activities) are also supported by the common communication platform provided by the enterprise network. An example of possible workgroup collaboration would be between technical staff through sharing and posting of technical bulletins, troubleshooting updates, and information concerning development or maintenance methodologies, platform integration (e.g., LAN, desktop), and experience with recent technology upgrades.

4.0 Comparison and Recommendation

Previous sections of this analysis have described and estimated life cycle costs for the four alternative solutions that respond to the current environment of disparate networks, excessive outages, and over-capacity that are symptomatic of the absence of central network management. This section compares these alternatives with each other and with the status quo to generate both financial and non-financial measures of the relative advantage to be derived from each.
Table 16 provides a high level summary of the life cycle costs for the four alternatives compared with the baseline costs. Section 2 of this analysis provides detailed back up for the summary information provided here.

Table 16 Life Cycle Cost Summary

Financial Measures	Alternative Zero Recapacitation	Alternative One Min. Redundancy	Alternative Two Med. Redundancy	Alternative Three Full Redundancy
Life Cycle cost	$366 M.	$286 M.	$293 M.	$296 M.
Savings over Baseline	$105 M. (22%)	$185 M. (39%)	$178 M. (38%)	$175 M. (37%)
Excess over lowest cost alternative	80 M. (28%)	________	7 M. (2%)	10 M. (3%)

4.1 Net Present Value

Net Present Value is an economic assessment methodology to help identify the most economically advantageous alternative. The costs of each alternative have different realization schedules based on the schedule for obtaining, implementing, and realizing the cost advantages of TEN. Present value converts future dollar amounts into current dollar figures through the application of expected cost of capital (discount rate). The underlying theory is that money spent today has a different value in the future based on the cost of money at both of those times. This theory can be revered to allow costs at two different times in the future to be compared in today's dollars, thereby permitting an even comparison.

Present Value Analysis is based on two principles:

1. The cost of perpetuating the current environment (baseline) is assumed to be the standard.
2. Present value is measured based on variance from the current environment (Net Present Value of zero is financially equivalent to the current environment).

The starting point for the Present Value analysis is current year of fiscal 1998. Present value calculations multiply both benefits and costs by a discount rate, or opportunity cost of capital, to present them in current year dollars. The real discount factor used in this analysis is 3.5%, which was obtained from OMB Circular A-94. The real discount factor is added to the projected rate of inflation (3%) to produce a nominal dollar discount factor of 6.5%.

Table 17 Net Present Value

	Alternative Zero Recapacitation	Alternative One Min. Redundancy	Alternative Two Med. Redundancy	Alternative Three Full Redundancy
Net Present Value	$76 M.	$133 M.	$128 M.	$125 M.

Based on net present value analysis, Alternative One, Minimum Redundancy, is projected to be the most favorable alternative, with projected discounted savings of approximately $133 million (Table 17). The differences between Alternatives One, Two, and Three are projected to be minimal (within 6%). Alternative Zero generates significantly lower savings and is clearly the least favorable alternative based on net present value analysis.

4.2 Return on Investment

The ROI expresses the difference between the baseline and each alternative as a rate of return based on the original investment. The greater the difference (savings) over the baseline, the greater the rate of return required to account for those differences. A complicating factor for calculating the ROI for Alternatives One, Two, and Three is determining the original investment. Because the capital expenditures for these alternatives are less than the baseline (due to the end-to-end service requirement of TEN contractor), the original investment cannot be expressed in terms of capital expenditures. An alternative approach expresses the investment in terms of the estimated salvage value for the Government Furnished Equipment (GFE) provided to the contractor. Even though GFE does not represent out-of-pocket expenditure, foregoing the salvage value associated with the router inventory represents an economic opportunity cost. Other components of the original investment for Alternatives One, Two, and Three include the Year 1 Program Management cost (necessary to acquire the contracted services and monitor installation of the network), and the Year 1 Contracted Services required to install, test, and begin operation of the network. Because Alternative Zero is indistinguishable from the Baseline scenario in terms of original investment, the original investment is defined as zero, invalidating calculation of ROI for Alternative Zero.

Table 18 Annualized Return on Investment

Financial Measures	**Alternative Zero Recapacitation**	**Alternative One Min. Redundancy**	**Alternative Two Med. Redundancy**	**Alternative Three Full Redundancy**
Investment	$0	$6.2 M.	$6.4 M.	$6.4 M.
Savings over Baseline	$105 M.	$185 M.	$178 M.	$175 M.
Return on Investment	________	219%	201%	176%

The acquisition strategy adopted can be expected to impact the initial investment required for the TEN project significantly. Using a multi-year acquisition, with appropriate options for cancellation, creates incentives for the most competitive contractors to amortize the TEN infrastructure and to incorporate the associated capital charges into the cost of operation. This approach represents an effective risk sharing strategy in conformance with the Information Technology Management Reform Act. In the absence of a risk sharing strategy (e.g., single year contracts or separable transition costs), the successful bidder recoups the cost of the TEN infrastructure initially, which then constitutes a barrier to entry for competing contractors during subsequent re-competition.

Based on ROI analysis, Alternative One, Minimum Redundancy, is projected to be the most favorable alternative, with an annualized return of greater than

200% (Table 18). Alternatives Two and Three generate lower ROIs, however, of the same order of magnitude. It should be noted that ROI projections are extremely sensitive to variations in investment level, so that the selection of a different method of computation for the original investment may alter the resultant ROI significantly. The relative ranking of ROIs is not effected by altering the computation of original investment. Figure 5 depicts the magnitude of the ROI, using cumulative return to illustrate the speed of the payback period (2 years) and the magnitude of the return compared to the initial investment.

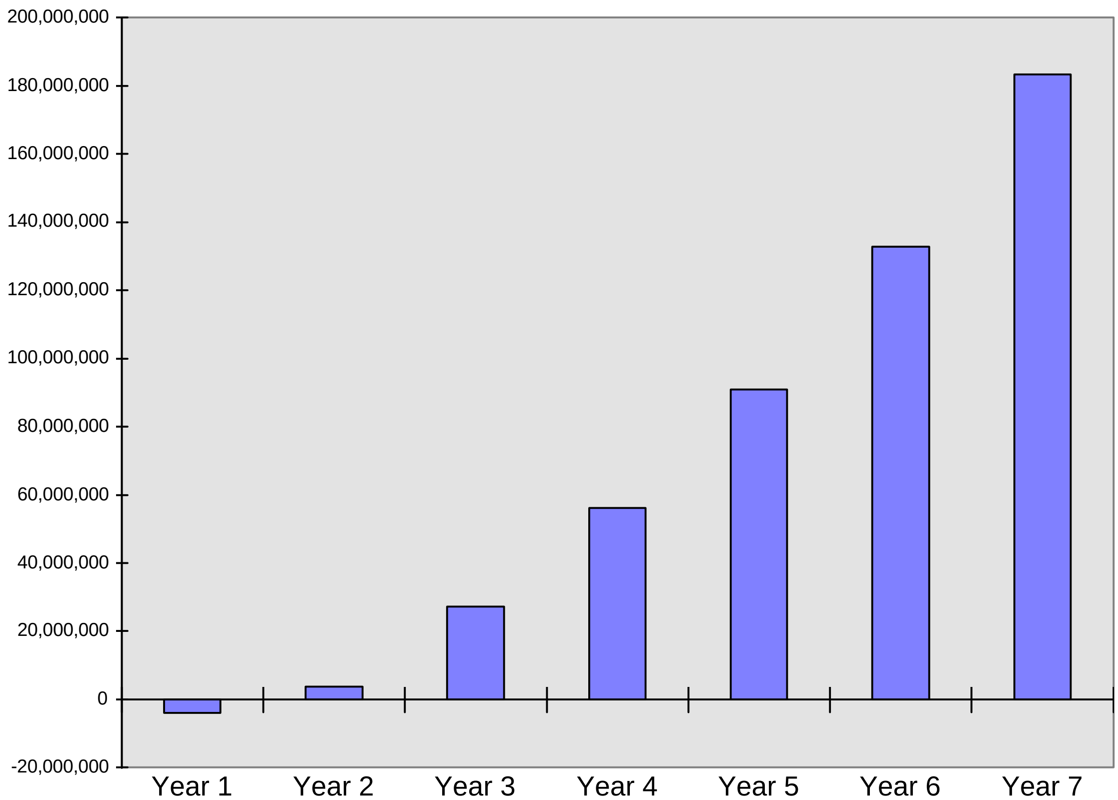

Figure 5 Cumulative Payback Associated with Alternative One

4.3 Sensitivity Analysis

Sensitivity of the cost estimates associated with each alternative to variances in the level or rate of change of attributes provides another perspective on the relative advantages of the alternatives. Table 19 describes sensitivity factors that apply to each alternative.

Table 19 Sensitivity to Cost Factor Variances

Varying Cost Factor	**Alternative Zero Recapacitation**	**Alternative One Min. Redundancy**	**Alternative Two Med. Redundancy**	**Alternative Three Full Redundancy**
Hardware & Software	Level and cost of technology-based items are stable in current platforms. Changes in future technologies may cause accelerated obsolescence of network assets.	Contract structure reduces reliance on asset base. Result is relatively lower vulnerability to technological obsolescence than in Alternative 0. Timing & level of reduction impact equally on Alternatives 2 & 3.	Same as Alternative 1.	Same as Alternatives 1 & 2.
Personnel-Related	Personnel savings are projected for other alternatives. If not achieved, favorable to this alternative, which assumed agency networks fully staffed. Exposure to personnel-related overage is significantly less.	Advantage relative to Alternative 0 is dependent on the reassignment of WAN technicians and management with reduction of personnel costs. Timing & level of reduction impact equally on Alternatives 2 & 3.	Same as Alternative 1.	Same as Alternatives 1 & 2.
Contracted Services	Minimal impact of change in rates or level of contracted services.	Greater exposure to change in rates/ level of contracted services compared to Alternative 0. Minimal impact compared to other TEN alternatives.	Same as Alternative 1.	Same as Alternatives 1 & 2.
Transmission Volume	Outage impact & transmission cost vary directly with volume, resulting in unfavorable cost impacts vs. 3 other alternatives.	Outage impacts are negatively affected by greater volume. Transmission cost (favorable for this alternative) offsets increased outages, yielding balanced overall impact.	Outage impacts & transmission cost are in between the extremes of other alternatives, and in opposite directions yielding negligible effects relative to other alternatives.	Outage impacts are favorably affected by greater volume since this configuration is the most survivable. Transmission cost for this alternative offsets savings from outages, resulting in overall minimal impact.
Transmission Pricing	This alternative is favorably affected vs. Alternative 3 (only), since transmission cost for Alternatives 1 & 2 is lower. Highest cost position of Alternative 0 is unchanged by variances of 100%	Relative advantage varies in the same direction as price; lower price trends reduce advantage for the "low-cost" alternative due to narrower range for transmission cost.	Alternative s 1 & 3 achieve advantage from higher and lower price trends respectively. Price movement fails to create a preference for this alternative.	Survivability becomes the determining factor as lower price trends narrow the cost range for transmission. This favors Alternative 3. Conversely, if prices drop more slowly or rise, transmission cost has unfavorable

	from current forecast levels.			effect.

The sensitivity factors identified in Table 19 address the primary causes of change in the financial model projections. The following major conclusions are evident from examining the sensitivity analysis:

- Alternative Zero requires a specific scenario of multiple, independent occurrences to have an impact on its relative standing. The chain of related events necessary for this alternative to become favorable includes decreases in predicted volume and price of transmission, failure to achieve personnel-related savings, and increases in contracted services. The level of variance from predicted levels would have to be significant (in the range of 25-50% for each factor) as well as trending universally in favorable directions. Because Alternative Zero is dependent on multiple factors to change its relative preference, the likelihood of common occurrence is considerably lessened.
- Alternatives One, Two, and Three are affected similarly by all factors, except those related to Transmission Volume and Pricing. Transmission Volume has counteracting effects on these alternatives, generating offsetting results in the cost of transmission and the operational impact of network outage. The most significant factor for separating these factors further is the price of transmission. Higher than projected pricing has the most favorable effect on Alternative One, because of its lower cost structure, based on less redundancy in the backbone infrastructure. In contrast, lower transmission pricing has a disproportionately favorable impact on Alternative Three. In neither case is Alternative Two affected favorably versus the other TEN alternatives, because its cost structure lies in between the more extreme alternatives.

4.4 Qualitative Factors

Based on the preceding financial analysis, Alternative Zero, Recapacitation, can be eliminated from further consideration due to higher life cycle cost and net present value than the TEN alternatives. The significantly better financial performance projected for Alternatives One, Two, and Three establishes these alternatives as the finalists from which the most advantageous alternative should be selected. Based on the close correspondence between these alternatives in terms of financial performance, qualitative factors should be considered in making the determination of the selected alternative.

Qualitative factors are based on the degree to which each alternative meets the project requirements. The overriding requirement of the TEN project is to efficiently manage USDA networks, comprising the following detailed requirements:

1. Reduce duplication of telecommunications services and equipment. Optimize usage of telecommunications consistent with the business processes.
2. Improve network performance (e.g., availability, elimination of bottlenecks).
3. Provide network capabilities wherever needed at the levels required (comparable to a utility). Link network resources to business requirements based on established criteria.
4. Provide improved accountability for telecommunications decisions (e.g., quickly and easily supply data for cost/benefit analyses).
5. Migrate USDA to the post-FTS2000 environment, and provide capabilities for network services to take advantage of new tariff structures (e.g., least cost routing).
6. Provide configuration management, i.e., ensure that networks are maintained in a fully operative, fully supportable state, including Y2K compliance. Configuration items include hardware, software, and other network components (e.g., circuits).
7. Be able to readily support new telecommunications requirements, including agency application initiatives, in a proactive fashion and determine needs early in the process.
8. Ensure appropriate network security.
9. Provide a methodology for network design and implementation as a repeatable process, able to respond to growing, changing requirements in the future.

The ability of each alternative to meet these requirements has been established by the design process, culminating in the Development of Initial Enterprise Design Alternatives—Task VI Report. Each of the network design alternatives has been developed based on the ability to support the requisite functions of management, problem resolution, throughput, and availability consistent with USDA needs. The primary difference between the alternatives centers on the second requirement, to improve network performance by enhancing availability and eliminating bottlenecks. In this regard, Alternative Three provides far greater survivability than Alternatives One or Two. Given the relative proximity of these alternatives in cost, and the greater congruence between Alternative Three and the TEN network requirements, the simplified decision facing USDA is the selection between two strategies: maximizing financial performance (Alternative One) or maximizing technical goal attainment (Alternative Three).

4.5 Recommendation

Consistent with the preceding financial analysis, the strategy of minimizing cost within acceptable technical performance parameters is generally recognized as a reasonable risk mitigation strategy. The relative performance weakness of

Alternative One in terms of outages and bottlenecks has been accounted for under the cost category—Operational Impact of Network Outages. Even considering the effects of additional outages, Alternative One is more cost effective. In addition, the most significant factor of the sensitivity analysis, Transmission Pricing, has a further favorable impact on Alternative One if prices de-escalate more slowly than projected. Given the aggressive assumptions on price decline associated with the FTS2000 follow-on contract, slower, rather than faster de-escalation seems to be the more probable variance from the projections. Under the stated assumptions, and considering likely variances from those assumptions, Alternative One is recommended as the most advantageous alternative.

PART TWO

Telecommunications Enterprise Network Design

Chargeback Method of Analysis

Task Order Request Under

GSA Schedule

PERFORMANCE ENGINEERING CORPORATION

1.0 Introduction

The cost of operations for the USDA Telecommunications Network (TEN) must be equitably distributed among USDA organizations. This document provides an evaluation of proposed cost recovery methods. The definition and evaluation criteria or each method are discussed. In addition, the effects of the existing network environment on chargegback methods are addressed. Finally, chargeback methods are compared relative to their support of the TEN operation. Based on the comparison, recommendations are provided for the most feasible chargeback method for the USDA TEN.

2.0 Methodology

The chargeback methodologies considered were identified from a variety of sources, including periodicals, white papers, Internet home pages, and product literature. Evaluation was based on both technological and operational issues, as well customer value and ease of use. Primary constraints placed on methodology selection included:

- consistency with the USDA business and operational requirements,
- compatibility with existing TEN monitoring and analyzing infrastructure,
- compatibility with current as well as proposed USDA network hardware and software, and
- adaptability to future design considerations.

One implementation scheme for chargeback takes the form of what is referred to as an “activity based” approach, which relates fixed attributes to a “bill” for telecommunication services. An example of this type of approach has been implemented by Intel Corporation, which has designated a single individual to administer chargeback for its $500 million per year network. Intel attributed this accomplishment to focusing on communications with its users to better meet their needs, and aligning its cost drivers with costs. By doing this they have realized a lower cost to the company, due to a minimal amount of monitoring required, and more meaningful and accurate communication with the company’s user community.

However, when there are multiple groups and sites, and a highly distributed infrastructure with multiple platforms and protocols, the approach taken has emphasized focus on (and ultimately control of) usage. A recent article appearing in *PC Week* (April 17, 1998) dealt with different ways of implementing chargeback to recover Internet costs, ranging from simple approaches comparable to the Intel example to highly involved methods involving extensive network monitoring. In addition to passive monitoring, the article addressed intrusive limitations on network utilization, such as limits on the size of electronic mail attachments. This growing emphasis on accounting for network utilization stems from the continued growth in Internet usage, impacting the operational processes of a growing number of organizations, and increasing at a previously unexpected rate.

It is evident from a review of the literature that the chargeback process can be implemented many ways, varying by degree of intrusiveness and complexity. To recover the costs of operating and maintaining the network infrastructure requires that an IT organization budget, manage, and track all network components and related expenses.

3.0 Issues Related to the Current Environment

In examining the current environment, as part of the engineering and financial analyses, some issues have surfaced with relevance to chargeback issues. These issues form the backdrop for the implementation of the selected chargeback approach, and are treated in the paragraphs that follow.

3.1 Current Network Topology

A limitation of the current architecture with respect to implementation of a chargeback system is the inability to monitor the entire network. The hardware elements vary greatly, as identified in the TEN Task I Report. The report identified various different types of routers from multiple vendors which brought varying degrees of complexity, and incompatibility between the routers and the network management tools. This was evident in the TEN Design Task I Report, Physical Baseline Definition of the USDA Data Networks, in that various routers had to be identified through a survey and not by the network tools. Incompatibility of network devices prevent comprehensive measurement of network usage and cost, which will be remedied by the TEN environment.

3.2 Outdated Hardware and Software

In addition, the Task I Report also identified how much of the current router equipment is either outdated or obsolete. This may be another reason why the routers are not visible by the network monitoring tools because they may use software applications that are too old for the network monitoring tools to see. For these obvious reasons and others that may exist, but were not identified, the current architecture would not allow for fair charges to be implemented and assessed in order to recover network costs.

Given these findings it is warranted to see if each design alternative supports the potential for recovering network costs through the evaluation of three possible chargeback methods. Each method will be discussed in the following sections.

4.0 Chargeback Methods

Chargeback is defined as a way of implementing a cost recovery mechanism that distributes costs to the user community on a basis that is perceived as fair and reasonable. In this regard, a key consideration in the construction of the chargeback system is the coverage of and conformance with the structure of the costs that are accumulated in the cost center. The following principal cost components must be incorporated into the operation of the TEN cost center:

- Personnel-based costs, which include the administrative effort associated with management of the TEN program, the engineering and design effort required to assess, plan, and architect network solutions, and the governance necessary for establishment of telecommunications policy and guidance. Costs associated with those personnel (such as office space, supplies and materials, and furniture and equipment) must also be included.
- Contractual costs, including the acquisition of contracted services to provide end-to-end services for providing, maintaining and operating TEN infrastructure
- Costs of transmission for access, bandwidth, and traffic associated with TEN feeder, concentrator, and backbone nodes.

Other costs have been examined within the Financial Analysis of Alternatives study, however, these costs (e.g., related to government-maintained equipment) are both smaller in scope, and less relevant to chargeback than the personnel, contractual, and transmission costs described previously. An example of costs that have been addressed within the financial analysis, that are irrelevant to chargeback analysis, would be the cyclical replacement of equipment on the periphery of the TEN environment that continues to be maintained by USDA (e.g., for SNA networks). Although these costs were included in the financial analysis to provide a comparable basis for assigning life-cycle costs between the baseline and alternatives, costs peripheral to the operation of IP-based, data networks would continue to be borne under current funding arrangements. Of course, full cost recovery, in conformance with Departmental Regulation 1043-40, governing working capital funding, would be instituted for the TEN program. The preceding discussion serves only to provide an overview of the TEN cost structure in order to highlight cost recovery issues relative to stability and predictability.
The importance of the TEN cost structure for chargeback methodologies is the consideration of stable, predictable charges for network services for TEN customers. Because the provision and maintenance of the TEN infrastructure is provided under contractual arrangement, and given careful management and control of government costs (chiefly personnel), large variances in the resultant costs to the working capital fund, which must be distributed to TEN users, will be avoided. This stability in two

out of three key cost components provides the option for additional alternatives beyond the utilization-based model, which is the most obvious solution within a network environment. Variation in transmission costs will still not be completely accountable without detailed monitoring of network traffic.

Given the cost structure described in the preceding paragraph, the following three alternatives approaches to recover the costs associated with implementing and operating a new network have been analyzed and compared.

- Static is based on fixed operational attributes like number of sites, number of users, etc.
- Capacity: is based on maximum utilization from a network bandwidth perspective, assuming that the network must be designed to support whatever throughput is possible.
- Utilization: is based on actual network traffic, as nearly as may be determined.
- The remaining paragraphs will detail the three chargeback methods.

4.1 Static Approach

This method addresses the use of fixed operational cost drivers with respect to telecommunications. A cost driver is anything that when changed will generate a corresponding change in cost. For example, IT organizations may charge for their services by the kilobyte transported. However, this may not be fair or may not recover costs for the IT management organization, because an increase in kilobytes transported does not necessarily result in increased costs, unless the network is at peak capacity. The static approach evaluated in this report will not look at costs drivers in a technical sense (e.g., kilobytes transported), but from a business sense. The business cost drivers may consist of items like the number of users, which usually has a direct correlation to the cost of the network. Industry-standard models, such as the Gartner Group's Total Cost of Ownership (TCO), allocate the costs of hub/switches, technical network support, and help desk for tiers 1, 2, and 3, on a per user basis. Numbers of users provide only a high-level approximation of network demand due to significant variations in communications requirements. A recent white paper on network capacity planning (by PDC Solutions) suggests separate categories of users, who have fundamentally distinct patterns of use. The relative usage of Internet is estimated by this paper to be three times as high for technical knowledge workers, as for process knowledge workers or for management workers. Other contributing factors that may be relevant for a static chargeback method are locations, which could be defined as either physical or IP addresses, as well as relative proximity to the rest of the network, and the number of application types that run on the network.

A static chargeback approach focusing on business drivers rather than technical drivers makes managing a network easier to understand from the end-user perspective because they can determine exactly what the charges are, although not necessarily how to influence them. This type of chargeback results in minimal monitoring being required in order to gather the required metrics.

4.2 Capacity-Based Approach

A capacity-based chargeback method would implement a cost recovery mechanism based on maximum bandwidth usage, under current methods, on committed information rate (CIR) or Dedicated Transmission Service (DTS). In addition to the current CIR/DTS pricing, it is possible that more dynamic pricing regimes will be available within the post-FTS 2000 environment. For example, service providers may price separately for “bursts” above the CIR, or dynamically re-allocate CIR, or provide true usage-based pricing. Given these possibilities within the post-FTS 2000 service offerings, the operational definition of “capacity” within the TEN environment is difficult to determine with precision. Some variability, therefore, is introduced into the measurement and re-billing of capacity. If capacity continues to be based on CIR/DTS, the instances of changes once the baseline has been established may be expected to be relatively intermittent. The introduction of burst-rate pricing, dynamic allocation of CIR, or usage-based pricing would create a much more dynamic environment, in which, fairly dramatic monthly swings in the transmission costs to the working capital fund could be anticipated, which, in turn, would have to be passed along to TEN subscribers. The complexity of information in the capacity based approach is roughly consistent with the previously described level of the static approach.

4.3 Utilization-Based Approach

The third methodology being evaluated is related to resource utilization. Data centers have historically charged for services based on utilization, including factors such as on-line regions, Central Processing Unit (CPU) seconds, disk storage, tape mounts, printlines, network connections, and similar resource demands. While the necessary information for operating chargeback systems for the elements described above has traditionally been readily obtained, either as part of operating system journals, or through widely available commercial products, network utilization information is, by its nature, more dispersed and only recently emphasized as a component of cost recovery systems. Therefore, the tools needed for a utilization-based approach will be, of necessity, more sophisticated and less available (as “turn-key” solutions) than for traditional information technology operations.

A principal decision point encountered in implementation of a utilization-based chargeback system centers on the design extremes posed by the minimization of transmission costs versus the reverse choice of minimizing infrastructure. Containing traffic associated with polling of remote nodes, at the expense of greater infrastructure costs incurred by remote positioning of traffic analyzers, is the root cause of this trade-off. The alternatives defined for the chargeback study treat each of the preceding design choices by posing two distinct options for the utilization-based approach: the first minimizing infrastructure, the second minimizing traffic overhead. The overriding premise of any utilization approach is that management traffic added to the network must be maintained within acceptable limits, due to the importance attached to reliable performance and high throughput as key goals of the TEN environment. An additional consideration is the cost-effectiveness of TEN services, of which chargeback is an important contributor.

The premise of the first utilization-based alternative is that the network analysis would be performed at backbone nodes, used to manage network performance while providing dual-use function for utilization data capture. The approach would rely on the periodic gathering of site statistics in order to sample the site's representative traffic load. Use of polling to interrogate the IP address origin and destination of a transmission implies that only a portion of the transmission constitutes redundant traffic because the data, which is the largest portion of the packet (the unit of transmission) is not relevant for assignment of chargeback cost. As long as the sampling interval was sufficiently infrequent, undue management traffic would not be created.

A more involved monitoring approach would require network analysis to be conducted below the backbone node. Because this level of utilization analysis requires frequent monitoring, rather than sampling, the necessary polling would constitute a much more significant burden on network traffic if the same approach (centralized monitoring) were used. Mitigation of this burden may be achieved through the use of remotely positioned, non-intrusive monitoring capabilities and off-peak transfer of traffic data to reduce requirements for additional bandwidth. Inquiries with vendors of network management information products yielded manageable ranges of transaction size from tens to hundreds of characters, depending on the frequency of transfer (fifteen minute or one hour intervals).

In addition to the two extreme design options, described above, other levels of monitoring are possible, which would yield intermediate results. The trade-offs being evaluated between infrastructure and transmission may lead to an approach combining facets of the central and remote monitoring approaches. For example, an intermediate level of infrastructure could require network analyzers to be positioned at the concentrator nodes.

5.0 Cost Elements

As discussed in the previous section, various cost elements may result from the implementation of a chargeback methodology. In this report, these cost elements will be categorized into three areas: infrastructure, effort, and transmission overhead. A definition of each category is as follows:

- Infrastructure: consists of the tools needed in order to carry out the chargeback functions. These tools may consist of hardware or software, including protocol analyzers or sniffers, traffic monitoring devices, and other equipment (e.g., workstations, disk and/or tape devices) depending upon which chargeback approach is implemented.
- Effort: consists of personnel resources (both government and contractor) needed to establish, operate, and maintain the chargeback process. These personnel resources may be needed for gathering and analyzing statistics, developing billing reports, managing overall chargeback operations.
- Transmission Overhead: concerns the amount of traffic added to the network to perform the chargeback function. Overhead is driven by the type of chargeback method implemented, the depth of data gathering (with respect to the levels of the network), and the frequency of collection.

5.1 Infrastructure-Based Chargeback Costs

Infrastructure consists of the tools needed in order to carry out the chargeback functions. These tools may consist of hardware or software, and may include components (e.g., protocol analyzers or sniffers) that serve dual functions, both as network management (related to TEN management) and traffic monitoring (to support chargeback). Much of the other equipment (e.g., workstations, disk and/or tape devices) needed to provide chargeback capability is expected to be available based on the general level of automation at both central and remote sites.

Because the static approach does not involve analysis of network activity, general-purpose office automation tools, assumed to be widely available, constitute the only hardware requirement. For the capacity-based and the central monitoring option of the utilization-based approach, the existing network management hardware and software would be anticipated to provide the capability for requisite traffic analysis, because centrally obtained information is anticipated to be sufficient. The only significant addition to the basic network management infrastructure is for the remote monitoring option of the utilization-based approach. In this case, the requirement for full network traffic information would be satisfied by remotely positioned traffic analyzers. The purchase of more than 1,000 licenses of software products that range from $1,000 to $2,000 per site represents an annualized cost approaching one half million dollars in additional network infrastructure to support remote monitoring utilization, a materially greater expenditure than the other approaches. Because the applications, which provide management-level traffic analysis, represent relatively “thin” applications, it has been assumed that the available processing capacity exists at network end-node locations to support these applications without additional purchase of hardware. If hardware platforms were required to support network analysis processing, an almost equal expenditure would be necessary, resulting in an approximately one million dollar requirement.

In addition to acquisition of infrastructure products, performing chargeback will require USDA to develop infrastructure, in the form of automated processes, to routinize the operational functions where possible. Analysis of this necessary automation has been broken down into the following areas:

- Collection
- Allocation
- Reconciliation
- Reporting
- Adjustment

5.1.1 Collection

Collection under the static approach, is not required on network traffic per se, reducing the necessity for complex data gathering capabilities. Rather, a spreadsheet-based or database form-based application is sufficient for the periodic (e.g., quarterly) updates to the handful of relevant fields, constituting site profile information. Collection of data under the capacity-based approach is comparable to the static approach, relying on simple (rather than recurring) data associated with each site. The intermittent nature of the collection process for both the static and capacity-based approaches permits the possibility of manual data entry or unsophisticated macro transfer into a spreadsheet-based or simple database forms application. For the central monitoring option of the utilization-based approach, the complication of temporal data necessitates additional complexity in the collection module to account for more complex data structures, including recurring fields and/or averages, ranges, or similar derived measures.

The development of billing systems for the remote monitoring option of the utilization approach would require an order of magnitude increase in the scope and complexity in the collection module. The required processing includes the transfer of data from analyzers positioned at network end nodes. Operation of this level of infrastructure will require significant installation customization and software enhancements for backup, periodic transmission, purging/archiving, and other automated processes. Due to the more extensive data capture requirement, support for this approach includes design and development of a data buffering and transfer methodology that will avoid overburdening the network.

5.1.2 Allocation

Under the static and capacity-based approaches, allocation simply constitutes an arithmetic computation based on fundamental variables (rather than derived values). This level of complexity is consistent with elementary spreadsheet manipulations. Under the central monitoring option of the utilization approach, the use of sampling implies statistical programs of some kind to interpret stochastic data and generate meaningful results, such as means, variances, etc. that may be used to gauge the reliability of the resulting analysis. The addition of analytical components add an order of magnitude to the complexity of the allocation module, which require algorithms that potentially exceed the capabilities of database forms programs, potentially adding the complexity of computational programs written in third generation language (3GL), e.g., “C”, or fourth generation languages (4GL), e.g., Foxpro. The availability of additional data also complicates the establishment of an agreed upon basis for cost recovery since the possibilities of factors, including derived factors such as usage variances (in lieu of point measurements or means) are greatly expanded. Although the decision process for arriving at an acceptable formulation for allocating costs does not necessarily complicate the resultant billing system, the process of agreeing on the approach may lengthen the resolution of issues as well as raising the possibility of changes due to new or malleable requirements that require programming modifications. The remote monitoring option utilization approach includes many of the same complications related to allocation as previously described for the central monitoring approach. Although use of full data rather than samples alleviates some of the requirement for statistical processing, substantial manipulation of raw measures may be anticipated due to continuous traffic measurements.

5.1.3 Reconciliation

Reconciliation processes derive their complexity directly from the scope and complexity of the factors and algorithms involved. The review required to reconcile the small number of factors (e.g., sites, staff, number of networked applications, etc.) involved in the static approach or the single factor involved in the capacity-based approach is straightforward and anticipated to require little automation. In contrast, the reconciliation of the utilization-based approach carries greater requirements for check routines to identify and correct gaps and overlaps in coverage in utilization data. In addition, historical comparison routines may be required to provide additional quality assurance, and to prepare explanatory support materials for the user community.

5.1.4 Reporting

For the static and capacity-based approaches reporting is constrained by the simpler data structure (few, non-recurring fields). Although more elaborate reports involving historical comparisons, for example, are possible, a more likely approach to this requirement would involve reproducing outputs from prior periods, rather than complicating the data structures. The complexity level for the utilization-based approach is variable, because the requirement would depend as much on the level of complexity demanded by the chargeback community as by intrinsic requirements of the data structure. Many times more involved reporting would be possible given the multi-faceted usage data captured under the utilization approaches, than under the static or capacity-based approaches.

5.1.5 Adjustment

Adjustment processes are equivalent in complexity to the collection processes because the underlying data structures are expanded to maintain mirror entries, especially if more involved computations are required such as moving averages (because adjusted data must be maintained as distinct from data captured by the collection module for purposes of audit trail).

5.1.6 Cost Estimation

Table 20 identifies the complexities associated with cost recovery systems in each category of chargeback approach. Based on assignment of programming effort using high-level metrics such as Primitive Functions that are appropriate estimating factors prior to requirements gathering phases of the software development life-cycle, a rough order of magnitude estimate may be obtained for each chargeback approach. The following high-level estimates are projected for cost recovery systems:

- For Static and Capacity-Based approaches, 5 simple modules, having no real-time components, parameter-driven processes, or other complicating factors, are equivalent to 1 to 3 months of effort for macro- or forms-based enhancements to commercial spreadsheet or database products. Using a metric of $15,000 per programmer month, this yields an estimate of $15,000 to $45,000.
- Utilization-Based (Central Monitoring) comprises 5 moderate to complex modules, equivalent to 8 to 24 months of effort, including both macros and/or forms, as well as 3GL or 4GL programs. At $15,000 per programmer month, this yields an estimate of $120,000 to $360,000.
- Utilization-Based (Remote Monitoring) comprises 5 modules of substantial complexity, including both real-time and parameter driven routines, equivalent to 16 to 48 months of effort, largely for systems-level programming. At $15,000 per programmer month, this yields an estimate of $240,000 to $720,000.

Although the effort estimates in the preceding paragraph establish one-time, rather than annual cost ranges, applying the systems life-cycle metric that development costs and maintenance costs can be expected to equalize within 4 years after implementation yields a 40% annualizing factor (based on industry standards in *Software Engineering Productivity: A Practical Guide* by C. Stevenson, p. 288). Application of this metric, for example, for the remote monitoring utilization approach would result in projected software development and maintenance costs of $96,000 to $288,000 annually (40% of $240,000 to $720,000). Cost estimates for all approaches are depicted in Figure 6.

APPLICATION MODULE	STATIC	CAPACITY	UTILIZATION (central monitor)	UTILIZATION (remote monitor)
Collection	**Simple:** initial population effort based on existing information with periodic updates	**Simple:** comparable to static approach in that data is single faceted	**Moderate:** usage measurements require complex data structured in timed segments	**Complex:** continuous usage data require real-time routines to validate, update, archive measures
Allocation	**Simple:** limited number of factors, which require minimal manipulation	**Simple:** single measure used for assignment of costs	**Moderate:** timed segments and statistical samples imply algorithms, and involved computations	**Moderate:** data is similar to central monitoring; sample vs. continuous data has little impact on data manipulation
Reconciliation	**Simple:** review of known factors and basic computations	**Simple:** single factor reduces potential for discrepancy	**Complex:** results must be reviewed for gaps/overlaps, and compared with prior periods	**Complex:** similar to central monitor
Reporting	**Simple:** limited to simplicity of contributing data	**Simple:** similar to static approach	**Variable:** highly dependent on the requirements of TEN constituents	**Variable:** highly dependent on the requirements of TEN constituents
Adjustment	**Simple:** directly related to the data structures defined in the collection area	**Simple:** (refer to collection)	**Moderate:** (refer to collection)	**Complex:** (refer to collection)

Table 20 Complexity of Cost Recovery System under TEN Chargeback Approaches

5.2 Effort-Based Chargeback Costs

One of the principal costs of operating the chargeback system is the cost of personnel, both government and contractor. Even though estimates of staff effort depend on the particular definition of how chargeback is implemented, some general tendencies are observable in the complexity and scope of the measurement effort.

5.2.1 Static approach

With the static approach, one to two individuals would be responsible for collection of the data, and maintenance of the allocation algorithms. Reporting may require the effort of another individual, or in some cases the capability may be provided by the same individuals who perform the collection and allocation. The reconciliation and adjustment processes are relatively straightforward, in the absence of complex data or complicated calculations. The principal focus of the reconciliation and adjustment efforts is the periodic refreshment of the cost recovery data to accommodate the additional charges. Given the relatively long intervals between the adjustment and reconciliation processes (bimonthly or quarterly, for instance) the addition of an additional individual as well as a supervisory position may be required, bringing the total staffing estimated in the range of three to six (3 - 6) personnel. Because the level of activity would be highly variable, with intense focus during the time periods coinciding with budget formulation, and fiscal year close, the staffing allocation for the operation of the chargeback system should be factored by approximately 50 percent. This allocation is consistent with the intensive effort during a several month period of each year, coupled with intermittent effort during the remainder of the year. Utilizing a metric of $80,000 per year for fully loaded government personnel yields an estimate of $120,000 to $240,000.

5.2.2 Capacity-based approach

The capacity-based approach this approach requires that network configuration information be maintained as the basis for cost recovery. The configuration information that is maintained by the TEN contractor as an integral part of underlying network management function does not represent additional effort. Receipt, transfer, reformatting, and manipulation of the configuration information requires the effort of one to two program management personnel. Although the primary effort will be initial, additional activity may be required depending how dynamic the network configuration becomes. The level of personnel required for maintaining a capacity-based system may also vary, depending on the transmission pricing options within the post-FTS 2000 environment. Depending on the capability to provide separate costs for “bursts” above the committed information rate (CIR), to dynamically re-allocate CIR, or to provide true usage-based pricing, the operational definition of “capacity” within the TEN environment is difficult to determine with precision. Some variability, therefore, is introduced into the measurement and re-billing of capacity. If capacity continues to be based on CIR, the instances of changes once the baseline has been established may be expected to be relatively intermittent. The introduction of burst-rate pricing, dynamic allocation of CIR, or usage-based pricing would create a much more dynamic environment, in which, fairly dramatic monthly swings in the transmission costs to the working capital fund, which, in turn, had to be passed along to TEN subscribers would be experienced. The complexity of information in the capacity-based approach is roughly consistent with the previously described level of the static approach. The additional complication for the capacity based approach is the potential requirement for technical specialties (given the uncertainties relative to the operation definition of "capacity" in the post-FTS 2000 environment). The more dynamic possibilities that lie beyond the current CIR-based pricing, may predicate more continuous staffing, as opposed to the more predictably part-time nature of the static approach. The resultant staffing profile for the capacity-based approach begins with the 3 - 6 staff level of the static approach described above, with the addition of a technically specialized position. Therefore, the anticipated staffing level for the capacity based approach should be within the range of 4 to 7 positions, varying from a 50% allocation (predicated on the current CIR pricing) to more nearly full-time staffing under the assumption of more dynamic pricing regimes within the post-FTS 2000 environment. Utilizing a metric of $80,000 per year for fully loaded government personnel yields an estimate of $160,000 to $560,000.

5.2.3 Utilization-based approach:

The responsibilities and level of government staffing required for the utilization approach is comparable to capacity-based approach under the assumption of dynamic (as opposed to CIR) capacity described in the preceding paragraph (4 to 7 positions, staffed full-time). In addition, contractor staffing, at the level of 1 to 2 positions would be required to maintain monitoring capability and to ensure/validate the information being gathered. Utilizing a metric of $80,000 per year for fully loaded government personnel and $120,000 for fully loaded contractor personnel yields an estimate of $440,000 to $800,000.

For the remote monitoring option, the contractor staffing estimated to accomplish the monitoring and management of this configuration equals between 3 to 7 (government staff would not be projected to change) and could be anticipated to be involved in establishing procedures for capturing data locally, maintaining the data until an appropriate time to transfer the data to the central repository, and reconciling the data afterwards to ensure (through examination of appropriate timestamps) that the data are complete without overlap. This level of staffing would also be necessary to perform installation, configuration, and set-up of network analyzers at remote sites. Utilizing a metric of $80,000 per year for fully loaded government personnel and $120,000 for fully loaded contractor personnel yields an estimate of $680,000 to $1,400,000.

5.3 Transmission Overhead Costs

Under the utilization-based approaches, transmission will be limited either by sampling (in the central monitoring approach) or through additional infrastructure used to reduce the undue burdens of network management (remote monitoring approach). The remote monitoring approach will also utilize data buffering and transfer methodology that does not overburden the network, which has been accounted for within the cost recovery systems category. The effect of these approaches on transmission costs can be expected to limit the traffic management overhead associated with chargeback to no more than a one to five percent incremental addition to overhead (approximately $100,000 to $500,000). Neither the static nor the capacity-based approach is expected to involve active monitoring of network traffic.

5.4 Cost Factor Summary

Due to the wide variation, and rough order of magnitude associated with the cost recovery cost factors, the summary of the preceding cost analysis is presented using both qualitative and quantitative displays. Table 21 compares the level of infrastructure, effort, and transmission overhead associated with each of the approaches, while Figure 6 depicts the cost range estimates derived from those factors.

		Capacity	Utilization Based	
Cost Element	Static	Based	Central Monitor	Remote Monitor
Infrastructure				
Network Infrastructure	N/A	N/A	N/A	significant
Cost Recovery Systems	simple	simple	moderate/complex	complex
Effort				
TEN Program Office	very low	low	significant	high
Contractor Personnel	N/A	N/A	none to low	significant
Transmission Overhead				
Additional Network Traffic	N/A	N/A	low (1-5%)	low (1-5%)

Table 21 Comparison of Costs Factors for TEN Chargeback Alternatives

6.0 Analysis of Results and Decision Strategy

Analysis of the cost data demonstrates, not surprisingly, that a static approach provides the lowest cost method. This method has the disadvantage of being the least representative of USDA business processes, and provides no incentive for closer examination of network use.

The capacity-based approach and the central monitoring option of the utilization-based approach add the USDA business relevance to the chargeback methodology, providing the incentive for closer examination of network use. While the utilization approach provides greater flexibility in the scope and timing of statistics gathered (rather simply the highest possible bandwidth), this flexibility may be anticipated to cost as much as one million dollars more annually than the capacity basis. One future possibility that may blur the distinction between capacity and utilization approaches is the possibility that the post-FTS 2000 environment might include the capability for dynamic capacity, which could be reviewed (with the requisite cost recovery systems) in much the same fashion as utilization, with extremely close connection to both the cost drivers and the underlying business processes.

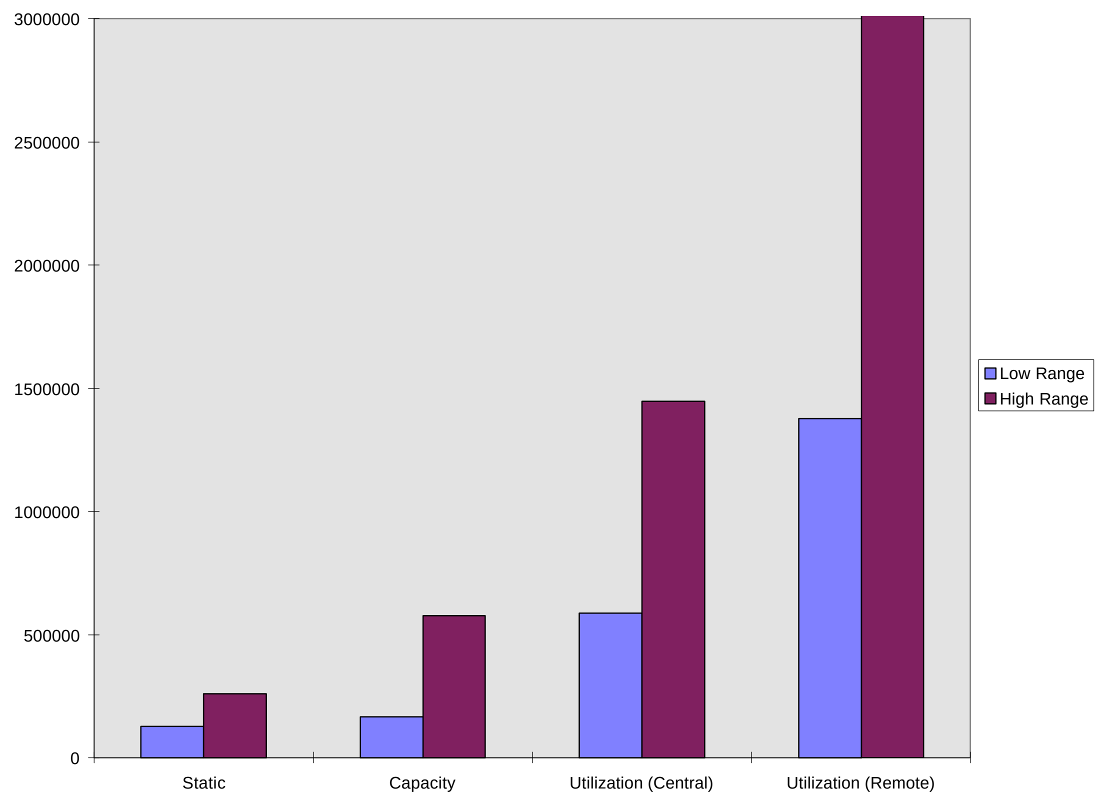

Figure 6 Comparative Annual Cost Estimates for TEN Chargeback Alternatives

The remote monitoring option of the utilization-based alternative achieves the most accurate representation of network usage, and should perform without taxing the overall network performance. A major advantage of this method is that by installing the necessary tools at the third tier of the network infrastructure, a firm relationship is maintained between usage and the chargeback bill (provided that multiple agencies do not reside on the same LAN). Security-related considerations apply more significantly to this method due to the requirement for equipment to be maintained at feeder nodes (extending the TEN footprint), with accompanying vulnerability to data corruption or compromise.

The additional cost associated with this method is significant, as much as one to 2.5 million dollars greater than other approaches. As shown in Figure 4, however, within the context of the entire TEN program, remote monitoring utilization-based chargeback would not constitute a major addition (approximately 5 percent). Because remote monitoring utilization ties chargeback for network services most closely to business processes, this approach provides for the greatest sensitivity to usage within the user community. As depicted in Figure 4, a 15 percent decline in transmission cost (due to decreased discretionary utilization) provides a compensating cost avoidance equivalent to the projected difference between Remote Utilization Chargeback and the average of the other methods. Given the prominence of Internet browser traffic in the current utilization profile, as documented by the Application Level Network Traffic Study (Task V Report), this level of cost avoidance is achievable. Figure 5 depicts current Internet usage patterns.

**based on the difference between the mid-point of estimated range for Remote*

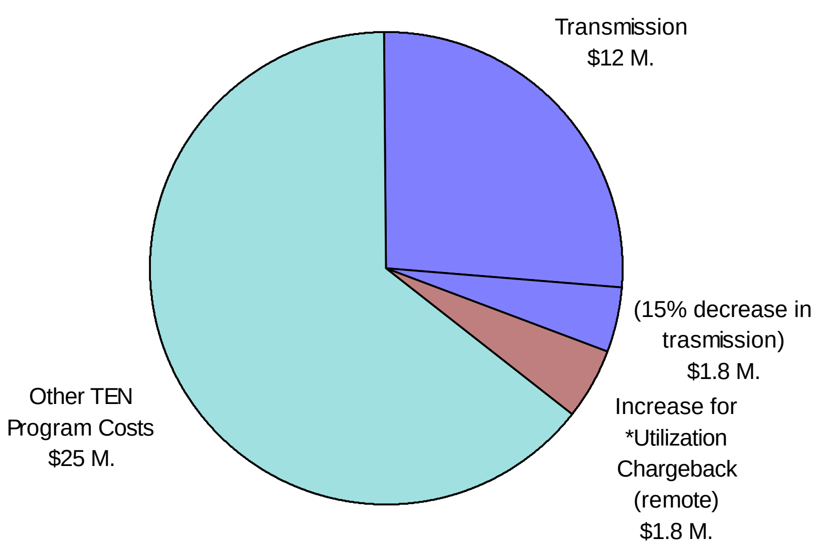

Figure 7 Added Annual cost of Remote Utilization Compared to TEN Program

Utilization Chargeback ($2.3 M.) and the average of the other methods ($ .5 M.)

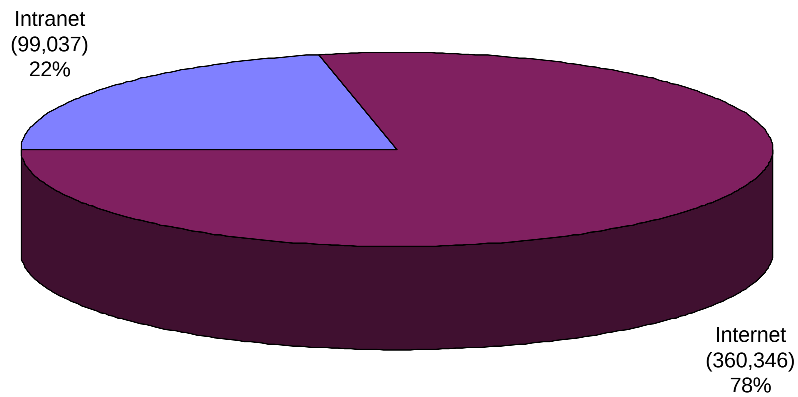

Figure 8 Distribution of Traffic Sessions Between the Internet and the Intranet

Despite the generally favorable prospects of instituting utilization-based chargeback, a necessary caveat with the remote monitoring approach is that even with analyzer presence at each node of the network, some utilization information may be unavailable. For example, differentiation between particular users within a single node on the network, e.g., the Service Center Agencies who share field offices, would not be possible without LAN- based monitoring down to the workstation IP address. Even with LAN-based monitoring, there still may be instances where allocation would have to be made under some other basis than network utilization statistics (for example, inbound traffic to a shared server).

An important non-cost issue is the predictability of the cost chargeback bills on a month to month and year to year basis. The greater predictability of a static approach or a capacity-based approach (assuming capacity remains based on CIR) follows from the less volatile nature of the underlying factors that drive these approaches. The demographic and application-based factors of the static approach may be expected to change much less frequently than usage. Similarly, capacity depends on a factor, which is tied to the upward bound of utilization, which would be expected to be less volatile than the short-term fluctuations. The apparent stability of either a static or capacity-based approach as compared to utilization assumes that point measurements are used without application of “smoothing” methodologies, such as moving averages. Utilization of multiple measures averaged over a period of time may eliminate some of the volatility of the point in time measurements.

7.0 Decision Strategy

The decision that USDA faces in selecting a chargeback method for TEN services depends on the level of detail and sensitivity to utilization required to be provided to TEN program and agency operational management staffs. Better usage information, the ability to answer inquiries, and introduction of incentives for monitoring and influencing network utilization require significantly greater expenditure, on the order of one to 2.5 million dollars annually.

In spite of its greater cost exposure, the utilization-based approach, using remote monitoring, merits serious consideration because of the linkage established between usage of and charge for network services. This relationship supports the business basis for provision of network services, and provides a governing incentive for the cost-effective use of new technologies, such as Internet-based applications. The utilization of passive monitoring (in lieu of polling-based techniques) and delayed transmission of traffic data, corresponding to off-peak time periods, avoid undue negative impacts to network performance. If the more involved cost recovery systems required for utilization-based chargeback are determined to be necessary, the aggressive timetable projected for the TEN project requires that consideration be given to utilization of a capacity-based approach as an interim solution. Reliance on a simpler chargeback approach at the outset could avoid delays to cost recovery systems due to greater complexity of utilization-based approaches.